Musculoskeletal Disorders and Workplace Factors

A Critical Review of Epidemiologic Evidence for Work-Related Musculoskeletal Disorders of the Neck, Upper Extremity, and Low Back

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FOREWORD

Musculoskeletal disorders (MSDs) were recognized as having occupational etiologic factors as early as the beginning of the 18th century. However, it was not until the 1970s that occupational factors were examined using epidemiologic methods, and the work-relatedness of these conditions began appearing regularly in the international scientific literature. Since then the literature has increased dramatically; more than six thousand scientific articles addressing ergonomics in the workplace have been published. Yet, the relationship between MSDs and work-related factors remains the subject of considerable debate.

Musculoskeletal Disorders and Workplace Factors: A Critical Review of Epidemiologic Evidence for Work-Related Musculoskeletal Disorders of the Neck, Upper Extremity, and Low Back will provide answers to many of the questions that have arisen on this topic over the last decade. This document is the most comprehensive compilation to date of the epidemiologic research on the relation between selected MSDs and exposure to physical factors at work. On the basis of our review of the literature, NIOSH concludes that a large body of credible epidemiologic research exists that shows a consistent relationship between MSDs and certain physical factors, especially at higher exposure levels.

This document, combined with other NIOSH efforts in this area, will assist us in our continued efforts to address these inherently preventable disorders.

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NOTE TO THE READER

This second printing of *Musculoskeletal Disorders and Workplace Factors: A Critical Review of Epidemiologic Evidence for Work-Related Musculoskeletal Disorders of the Neck, Upper Extremity, and Low Back* incorporates a number of editorial changes, including grammar, formatting, and consistency issues that were identified in the first printing. In addition, the notation of Dr. Lawrence Fine as co-editor was inadvertently omitted in the first printing and has been re-inserted.

The conclusions of the document in terms of decisions regarding the weight of the existing epidemiologic evidence for the relationship between workplace factors and musculoskeletal disorders remain unchanged. The following technical inconsistencies or errors were corrected:

Page 2-14: Text was corrected to reflect that five studies (as opposed to three) examined the relationship between force and musculoskeletal disorders of the neck.

Page 2-28: For Viikari-Juntura [1994], the “NR” entry in the Risk Indicator column was replaced with the value 3.0.

Page 2-34: Bergqvist [1995a] was changed to Bergqvist [1994]. The Risk Indicator entry for this study was changed from 4.4 to 3.7 (both noted as statistically significant), the entry for Physical Examination was changed from “Yes” to “No,” and the entry for Basis for Assessing Exposure was changed from “job titles or self-reports” to “observation or measurements.”

Page 3-3: Text was corrected to reflect that four studies (as opposed to three) met all four evaluation criteria. A description of Kilbom and Persson [1987] was moved forward in the chapter to this section and includes a clarification that health outcome in their study was based on symptoms and physical findings.

Page 3-32: The confidence interval depicted for Ohlsson [1994] was corrected to show a range from 3.5 to 5.9.

Page 3-69: Schibye et al. [1995] was added to Table 3-5.

Page 4-25: Dimberg [1989] was changed to Dimberg [1987].

Page 5a-3: Text was corrected to reflect that nineteen studies (as opposed to fifteen) reported results on the association between repetition and carpal tunnel syndrome (CTS). Text was also corrected to reflect that five studies (as opposed to four) met the four evaluation criteria for addressing repetitiveness and CTS. A description of Osorio et al. [1994] was moved forward in the chapter to this section.

Page 5a-15: Text was corrected to reflect that eleven studies (as opposed to ten) reported results on the association between force and CTS and that four (as opposed to three) met all four evaluation criteria. Descriptions of Moore and Garg [1994] and Osorio et al. [1994] were moved forward in the chapter to this section.

Page 5a-19 : The discussion (strength of association, temporality, consistency of association, coherence of evidence, and exposure-response relationship) of force and CTS was inadvertently omitted in the first printing and has been re-inserted.

Page 5a-27: The Risk Indicator for Osorio et al. [1994] was changed from 4.6 to 6.7, and for Nathan [1992], the “No association” entry under Risk Indicator was changed to a value of 1.0.

Page 5a-29: Stetson et al. [1993] was moved to the bottom of the table, and entries for Nathan et al. [1992] and McCormack et al. [1990] were added.

Page 5a-31: This table was modified to more accurately reflect the text.

Page 5a-33: For Koskimies et al. [1990], the entry for Basis for Assessing Exposure was changed from “observation or measurements” to “job titles or self-reports.”

Page 5b-1: Text was corrected to reflect that seven studies (as opposed to eight) are referenced on Table 5b-1.

Page 5c-4: Text was corrected to reflect that five studies (as opposed to four) met three of the criteria. A brief description of Kivekäs et al. [1994] was added to this section.

A number of references were clarified, and full references for studies that were cited in the text of the first printing but were inadvertently omitted from the reference list were added.

Appendix C was added to the document to provide a concise overview of the studies reviewed relative to the evaluation criteria, risk factors addressed, and other issues.

CONTENTS

EXECUTIVE SUMMARY

The term musculoskeletal disorders (MSDs) refers to conditions that involve the nerves, tendons, muscles, and supporting structures of the body. The purpose of this NIOSH document is to examine the epidemiologic evidence of the relationship between selected MSDs of the upper extremity and the low back and exposure to physical factors at work. Specific attention is given to analyzing the weight of the evidence for the strength of the association between these disorders and work factors.

Because the relationship between exposure to physical work factors and the development and prognosis of a particular disorder may be modified by psychosocial factors, the literature about psychosocial factors and the presence of musculoskeletal symptoms or disorders is also reviewed. Understanding these associations and relating them to the cause of disease is critical for identifying exposures amenable to preventive and therapeutic interventions.

MAGNITUDE OF THE PROBLEM

The only routinely collected national source of information about occupational injuries and illnesses of U.S. workers is the Annual Survey of Occupational Injuries and Illnesses conducted by the Bureau of Labor Statistics (BLS) of the U.S. Department of Labor. The survey, which BLS has conducted for the past 25 years, is a random sample of about 250,000 private sector establishments and provides estimates of workplace injuries and illnesses on the basis of information provided by employers from their OSHA Form 200 log of recordable injuries and illnesses.

For cases involving days away from work, BLS reports that in 1994 (the last year of data available at the time this report was prepared), approximately **705,800** cases (32%) were the result of overexertion or repetitive motion. Specifically, there were

- **367,424** injuries due to overexertion in lifting (65% affected the back); **93,325** injuries due to overexertion in pushing or pulling objects (52% affected the back); **68,992** injuries due to overexertion in holding, carrying, or turning objects (58% affected the back). Totaled across these three categories, **47,861** disorders affected the shoulder.

- **83,483** injuries or illnesses in other and unspecified overexertion events.

- **92,576** injuries or illnesses due to repetitive motion, including typing or key entry, repetitive use of tools, and repetitive placing, grasping, or moving of objects other than tools. Of these injuries or illnesses, 55% affected the wrist, 7% affected the shoulder, and 6% affected the back.

Data for 1992 to 1995 indicate that injuries and illnesses requiring days away from work declined 19% for overexertion and 14% for repetitive motion. The incidence rate of overexertion (in lifting) declined from 52.1 per 10,000 workers in 1992 to 41.1 in 1995; the incidence rate for repetitive motion disorders declined from 11.8 per 10,000 workers in 1992 to 10.1 in 1995. These declines are similar to those seen for cases involving days away from work from all causes of injury and illness.

The reasons for these declines are unclear but may include: a smaller number of disorders could be occurring because of more intensive efforts to prevent them; more effective prevention and treatment programs could be reducing days away from work; employers or employees may be more reluctant to report or record disorders; or the criteria used by health care providers to diagnose these conditions could be changing.

IDENTIFICATION AND SELECTION OF STUDIES

The goal of epidemiologic studies is to identify factors that are associated (positively or negatively) with the development or recurrence of adverse medical conditions. This evaluation and summary of the epidemiologic evidence focuses chiefly on disorders that affect the neck and the upper extremity, including tension neck syndrome, shoulder tendinitis, epicondylitis, carpal tunnel syndrome, and hand-arm vibration syndrome, which have been the most extensively studied in the epidemiologic literature. The document also reviews studies that have dealt with work-related back pain and that address the way work organizational and psychosocial factors influence the relationship between exposure to physical factors and work-related MSDs. The literature about disorders of the lower extremity is outside the scope of the present review.

A search strategy of bibliographic databases identified more than 2,000 studies. Because of the focus on the epidemiology literature, studies that were laboratory-based or that focused on MSDs from a biomechanical standpoint, dealt with clinical treatment of MSDs, or had other nonepidemiologic orientation were eliminated from further consideration for this document. Over 600 studies were included in the detailed review process.

METHODS FOR SYNTHESIZING STUDIES

For the upper extremity studies included in this review, those which used specific diagnostic criteria, including physical examination techniques, were given greater consideration than studies that used less specific methods to define health outcomes. The review focused most strongly on observational studies whose health outcomes were based on recognized symptoms and standard methods of clinical examination. For completeness, those epidemiologic studies that based their health outcomes on reported symptoms alone were also reviewed. For the low-back studies included in this review, those which had objective exposure measurements were given greater consideration than those which used self-reports or other measures. For the psychosocial section, any studies which included measurement or discussion of psychosocial factors and MSDs were included.

No single epidemiologic study will fulfill all criteria to answer the question of causality. However, results from epidemiologic studies can contribute to the evidence of causality in the relationship between workplace risk factors and MSDs. The framework for evaluating evidence for causality in this review included strength of association, consistency, temporality, exposure-response relationship, and coherence of evidence.

Using this framework, the evidence for a relationship between workplace factors and the development of MSDs from epidemiologic studies is classified into one of the following categories:

> **Strong evidence of work-relatedness (+++).** A causal relationship is shown to be very likely between intense or long-duration exposure to the specific risk factor(s) and MSD when the epidemiologic criteria of causality are used. A positive relationship has been observed between exposure to the specific risk factor and MSD in studies in which chance, bias, and confounding factors could be ruled out with reasonable confidence in at least several studies.
>
> **Evidence of work-relatedness (++).** Some convincing epidemiologic evidence shows a causal relationship when the epidemiologic criteria of causality for intense or long-duration exposure to the specific risk factor(s) and MSD are used. A positive relationship has been observed between exposure to the specific risk factor and MSD in studies in which chance, bias, and confounding factors are not the likely explanation.
>
> **Insufficient evidence of work-relatedness (+/0).** The available studies are of insufficient number, quality, consistency, or statistical power to permit a conclusion regarding the presence or absence of a causal association. Some studies suggest a relationship to specific risk factors, but chance, bias, or confounding may explain the association.
>
> **Evidence of no effect of work factors (-).** Adequate studies consistently show that the specific workplace risk factor(s) is not related to development of MSD.

The classification of results in this review by body part and specific risk factor is summarized in Table 1.

Table 1. Evidence for causal relationship between physical work factors and MSDs

Body part *Risk factor*	**Strong evidence (+++)**	**Evidence (++)**	**Insufficient evidence (+/0)**	**Evidence of no effect (-)**
Neck and Neck/shoulder				
Repetition		T		
Force		T		
Posture	T			
Vibration			T	
Shoulder				
Posture		T		
Force			T	
Repetition		T		
Vibration			T	
Elbow				
Repetition			T	
Force		T		
Posture			T	
Combination	T			
Hand/wrist				
Carpal tunnel syndrome				
Repetition		T		
Force		T		
Posture			T	
Vibration		T		
Combination	T			
Tendinitis				
Repetition		T		
Force		T		
Posture		T		
Combination	T			
Hand-arm vibration syndrome				
Vibration	T			
Back				
Lifting/forceful movement	T			
Awkward posture		T		
Heavy physical work		T		
Whole body vibration	T			
Static work posture			T	

CONCLUSIONS

A substantial body of credible epidemiologic research provides strong evidence of an association between MSDs and certain work-related physical factors when there are high levels of exposure and especially in combination with exposure to more than one physical factor (e.g., repetitive lifting of heavy objects in extreme or awkward postures [Table 1]).

The strength of the associations reported in the various studies for specific risk factors after adjustments for other factors varies from modest to strong. The largest increases in risk are generally observed in studies with a wide range of exposure conditions and careful observation or measurement of exposures.

The consistently positive findings from a large number of cross-sectional studies, strengthened by the limited number of prospective studies, provides *strong evidence* (+++) for increased risk of work-related MSDs for some body parts. This evidence can be seen from the strength of the associations, lack of ambiguity in temporal relationships from the prospective studies, the consistency of the results in these studies, and adequate control or adjustment for likely confounders. For some body parts and risk factors, there is some *epidemiologic evidence* (++) for a causal relationship. For still other body parts and risk factors, there is either an insufficient number of studies from which to draw conclusions or the overall conclusion from the studies is equivocal. The absence of existing epidemiologic evidence should not be interpreted to mean there is no association between work factors and MSDs.

In general, there is limited detailed quantitative information about exposure-disorder relationships between risk factors and MSDs. The risk of each exposure depends on a variety of factors such as the frequency, duration, and intensity of physical workplace exposures. Most of the specific exposures associated with the *strong evidence* (+++) involved daily whole-shift exposure to the factors under investigation.

Individual factors may also influence the degree of risk from specific exposures. There is evidence that some individual risk factors influence the occurrence of MSDs (e.g., elevated body mass index and carpal tunnel syndrome or a history of past back pain and current episodes of low-back pain). There is little evidence, however, that these individual factors interact synergistically with physical factors. All of these disorders can also be caused by nonwork exposures. The majority of epidemiologic studies involve health outcomes that range in severity from mild (the workers reporting these disorders continue to perform their routine duties) to more severe disorders (workers are absent from the workplace for varying periods of time). The milder disorders are more common. A limited number of studies investigate the natural history of these disorders and attempt to determine whether continued exposure to physical factors alters their prognosis.

The number of jobs in which workers routinely lift heavy objects, are exposed on a daily basis to whole-body vibration, routinely perform overhead work, work with their necks in chronic flexion position, or perform repetitive forceful tasks is unknown. While these exposures do not occur in most jobs, a large number of workers may indeed work under these conditions. The BLS data indicate that the total employment is over three million in the industries with the highest incidence rates of cases involving days away from work from overexertion in lifting and repetitive motion. Within the highest risk industries, however, it is likely that the range of risk is substantial depending on the specific nature of the physical exposures experienced by workers in various occupations within that industry.

This critical review of the epidemiologic literature identified a number of specific physical exposures strongly associated with specific MSDs when exposures are intense, prolonged, and particularly when workers are exposed to several risk factors simultaneously. This scientific knowledge is being applied in preventive programs in a number of diverse work settings. While this review has summarized an impressive body of epidemiologic research, it is recognized that additional research would be quite valuable. The MSD components of the National Occupational Research Agenda efforts are principally directed toward stimulation of greater research on MSDs and occupational factors, both physical and psychosocial. Research efforts can be guided by the existing literature, reviewed here, as well as by data on the magnitude of various MSDs among U.S. workers.

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CHAPTER 1
Introduction

PURPOSE

This document examines the epidemiologic evidence that associates selected musculoskeletal disorders (MSDs) of the upper extremity and the low back with exposure to physical factors at work. The authors have paid particular attention to analyzing the strength of the association between MSDs and work factors. Because the development of an MSD may be modified by psychosocial factors, the authors have also reviewed the literature on the relationship of these factors to the presence of musculoskeletal symptoms or disorders. Understanding these associations and relating them to disease etiology is critical to identifying workplace exposures that can be reduced or prevented.

BACKGROUND

The World Health Organization has characterized “work-related” diseases as multifactorial to indicate that a number of risk factors (e.g., physical, work organizational, psychosocial, individual, and sociocultural) contribute to causing these diseases [WHO 1985]. One important reason for the controversy surrounding work-related MSDs is their multifactorial nature. The disagreement centers on the relative importance of multiple and individual factors in the development of disease. The same controversy has been an issue with other medical conditions such as certain cancers and lung disorders—both of which have multiple causal factors (occupational and nonoccupational).

The goal of epidemiologic studies is to identify factors (such as physical, work organizational, psychosocial, individual, and sociocultural factors) that are associated positively or negatively with the development or recurrence of adverse medical conditions. This document addresses and evaluates the literature with regard to these issues for work-related MSDs.

This document reviews the epidemiologic evidence regarding the role of physical factors in the development of MSDs for the following body areas: the neck, shoulder, elbow, hand/wrist, and back. The document also addresses the influence of work organizational and psychosocial factors on the association of physical factors with work-related MSDs. This evaluation and summary of the epidemiologic evidence focuses chiefly on disorders affecting the neck and the upper extremity—including tension neck syndrome, shoulder tendinitis, epicondylitis, carpal tunnel syndrome, and hand-arm vibration syndrome, which have been the most extensively studied in the epidemiologic literature. This document also concentrates on studies that have dealt with the issue of work-related back pain and sciatica. The literature on disorders of the lower extremities is beyond the scope of this review.

SCOPE AND MAGNITUDE OF THE PROBLEM

The only routinely published, national source of information about occupational injuries and illnesses in U.S. workers is the Annual Survey of Occupational Injuries and Illnesses (ASOII) conducted by the Bureau of Labor Statistics (BLS) of the U.S. Department of Labor. This survey is a random sample of about 250,000 private-sector establishments, but it excludes self-employed workers, farms with fewer than 11 employees, private households, and all government agencies. The ASOII provides estimates of workplace injuries and illnesses from information that employers provide to BLS from their OSHA Form 200 log of recordable injuries and illnesses.

BLS has conducted this annual survey since 1972 and has thus provided basic information about cases of occupational injury or illness that required more than first-aid (including medical treatment, restricted work activity, or days away from work). This information includes the total number of cases categorized on the OSHA Form 200 log as either an injury or an illness. The illness data are separated into six subcategories; the category that contains most (but not all) musculoskeletal conditions is *disorders associated with repeated trauma*. This illness category also includes *illnesses associated with noise-induced hearing loss*, but MSDs account for the largest proportion of these cases, especially in recent years. All back disorders or injuries are placed in the single, broad *injury* category, which also includes all other types of injuries such as lacerations, fractures, and burns.

From this part of the ASOII, BLS reports that in 1995, 308,000 (or 62%) of all illness cases were due to disorders associated with repeated trauma (excluding low-back disorders, which are listed as injuries). The number of repeated trauma cases increased dramatically, rising steadily from 23,800 in 1972 to 332,000 in 1994—a 14-fold increase. In 1995, the number of cases decreased by 7% to 308,000 reported cases; but this number still exceeds the number of cases in any year before 1994.

Because these summary data did not adequately describe the nature of occupational injuries and illnesses and the related risk factors, the ASOII was redesigned in 1992 to capture more detailed information about injury and illness cases requiring days away from work. This redesigned survey captures demographic information about injured workers as well as the following characteristics of the injury or illness: (1) the employer's description of the *nature* of the injury or illness, such as sprain or carpal tunnel syndrome; (2) the *part of the body affected* by the specified condition, such as back or wrist; (3) the *source of the injury or illness* that directly produced the disabling condition, such as a crate, heavy box, or a nursing home patient; and (4) the *event or exposure* that describes the manner in which the injury or illness was inflicted, such as overexertion during lifting or repetitive motion. The BLS data are based on information provided by employers from their records of work-related injuries and illnesses and then coded into these categories.

For injury and illness cases involving days away from work, BLS reports that in 1994 (the last year for which the detailed data were complete when this report was prepared), approximately **705,800** cases (32%) resulted from overexertion or repetitive motion. Specifically:

- **367,424** injuries were due to overexertion in lifting; 65% affected the back. Another **93,325** injuries were due to overexertion in pushing or pulling objects; 52% affected the back. In addition, **68,992** injuries were due to overexertion in holding, carrying, or turning objects; 58% affected the back. Totaled across these three categories, **47,861** disorders affected the shoulder. The median time away from work from overexertion injuries was 6 days for lifting, 7 days for pushing/pulling, and 6 days for holding/carrying/turning.

- **83,483** injuries or illnesses occurred in other and unspecified overexertion events.

- **92,576** injuries or illnesses occurred as a result of repetitive motion, including typing or key entry, repetitive use of tools, and repetitive placing, grasping, or moving of objects other than tools. Of these repetitive motion injuries, 55% affected the wrist, 7% affected the shoulder, and 6% affected the back. The median time away from work was 18 days as a result of injury or illness from repetitive motion.

The highest incidence rates (IRs) of work-related injuries and illnesses from over- exertion occur among workers in nursing and personal care facilities, scheduled air transportation, and manufacturing of travel trailers and campers. As Table 1–1 indicates, these industries have rates of overexertion disorders four times higher than the average rate for all private industry. More than 2 million workers are employed in the three highest-risk industries alone. However, rates are not available by occupation within these industries, and not all workers within a high-risk industry will be at equal risk of developing a work-related MSD.

Industries with the highest IRs of work-related injuries and illnesses from repetitive motion include a number of garment manufacturing sectors such as knit underwear mills, men's and boy's work clothes, and hats, caps, and millinery; these industries also include manufacturing sectors such as textile bags, potato chip and similar snacks, motor vehicles, and meat packing plants (Table 1–2). These industries have IRs that are more than eight times the rate for all private industry.

Not all workers in these high-risk industries are exposed to the working conditions associated with these clearly elevated rates of illnesses and injuries from overexertion and repetitive motion; however, smaller proportions of workers in other industries may be similarly exposed. For example, trucking and courier services, an industry employing over 1.6 million people, had IRs for overexertion disorders that were almost three times higher than the average rate for all private industries. Thus, these employment estimates provide a conservative approximation of the number of workers with heavy exposures to high-risk conditions.

The BLS data are surveillance information that might contain misclassifications of both exposure and health outcomes. However, some industries have notably and consistently elevated rates of musculoskeletal injuries and disorders that are not likely to be attributable to data collection or coding. Note that decisions about the event or exposure that resulted in an injury or illness are associations rather than causal inferences. Nevertheless, they provide some perspective on the magnitude of work-related MSDs.

Table 1-1. Private sector industries with the highest incidence rates of injuries and illnesses from overexertion resulting in days away from work, 1994

Industry*	SIC code†	1994 annual average employment‡ (in thousands)	Incidence rate (per 10,000 workers)	95% confidence interval (rate per 10,000)	Number of cases
Nursing and personal care facilities	805	1,648	318.0	(286, 350)	41,884
Air transportation, scheduled	451	607	306.7	(276, 337)	16,309
Travel trailers and campers (manufacturing)	3792	22	303.7	(206, 401)	635
Food products machinery (manufacturing)	3556	24	260.1	(142, 378)	620
Bottled and canned soft drinks (manufacturing)	2086	95	255.6	(224, 287)	2,512
Beer, wine, and distilled beverages (wholesale)	518	150	254.6	(189, 321)	3,750
Coal mining	12	112	235.6	not available	2,609
Mattresses and bedsprings (manufacturing)	2515	31	233.5	(172, 295)	719
Comparison Industries:					
All manufacturing	2, 3	18,319	83.00	(81.4, 84.6)	151,794
All private industry§		94,146	76.00	(75.7, 76.3)	613,251
Finance, insurance, and real estate	6	6,707	17.90	(16.5, 19.3)	11,191

Source: Bureau of Labor Statistics, U.S. Department of Labor, Annual Survey of Occupational Injuries and Illnesses, 1994 Case and Demographic Resource Tables (ftp://stats.bls.gov/pub/special.requests/ocwc/osh/c_d_data).

*High rate industries were those having an incidence rate greater than three times the rate for all private industry, at the most detailed or lowest SIC level at which rates are published. Generally, manufacturing industries are published at the 4-digit code level and the remaining industries at the 3-digit level.

†*Standard Industrial Classification Manual*, 1987 edition.

‡Annual average employment from the BLS Covered Employment and Wages (ES-202) Survey.

§Excludes farms with fewer than 11 employees.

Table 1-2. Private sector industries with the highest incidence rates of injuries and illnesses from repetitive motion resulting in days away from work, 1994

Industry[*]	SIC code[†]	1994 annual average employment[‡] (in thousands)	Incidence rate (per 10,000 workers)	95% confidence interval (rate per 10,000)	Number of cases
Knit underwear mills (manufacturing)	2254	25	165.6	(145, 187)	370
House slippers (manufacturing)	3142	3	146.3	(92, 201)	48
Men's and boy's work clothes (manufacturing)	2326	42	117.2	(97, 137)	463
Textile bags (manufacturing)	2393	11	115.7	(60, 171)	117
Potato chips and similar snacks (manufacturing)	2096	35	115.2	(95, 135)	406
Motor vehicles and car bodies (manufacturing)	3711	335	113.9	(99, 129)	4,058
Hats, caps, and millinery (manufacturing)	235	21	103.9	(79, 129)	202
Meat packing plants (manufacturing)	2011	138	98.5	(76, 121)	1,402
Bras, girdles, and allied garments (manufacturing)	2342	12	96.2	(73, 119)	111
Wood products, not elsewhere classified (manufacturing)	2499	58	92.8	(69, 117)	515
Men's and boy's suits and coats (manufacturing)	231	40	89.1	(74, 104)	320
Electronic coils and transfers (manufacturing)	3677	17	87.0	(52, 122)	142
Men's footwear (excluding athletic)	3143	28	84.9	(64, 106)	221
Comparison Industries:					
All manufacturing	2, 3	18,319	27.0	(26.4, 27.6)	49,278
All private industry[§]		94,146	11.5	(11.4, 11.6)	92,576
Finance, insurance, and real estate	6	6,707	8.1	(7.4, 8.8)	5,046

Source: Bureau of Labor Statistics, U.S. Department of Labor, Annual Survey of Occupational Injuries and Illnesses, 1994 Case and Demographic Resource Tables (ftp://stats.bls.gov/pub/special.requests/ocwc/osh/c_d_data).

[*]High rate industries were those having an incidence rate greater than three times the rate for all manufacturing workers at the most detailed or lowest SIC level at which rates are published. Generally, manufacturing industries are published at the 4-digit code level and the remaining industries at the 3-digit level.

[†]*Standard Industrial Classification Manual*, 1987 edition.

[‡]Annual average employment from the BLS Covered Employment and Wages (ES-202) Survey.

[§]Excludes farms with fewer than 11 employees.

The large number of work-related low-back injuries or illnesses reported in the BLS data is consistent with the results of two representative surveillance studies in the United States and Ontario. In the U.S. study, about 52% of the back pain reports were attributed by the worker to repetitive events at work, and an additional 16% were attributed to discrete, acute events at work; 33% were associated with both types of exposures [Guo et al. 1995].

Although workers often consider MSDs to be work-related, their reports of back pain do not appear to affect the reliability of their self reports about exposure to physical work. In the Ontario study [Liira et al. 1996], 24% of the long-term back disorders were related to bending and lifting, working with vibrating machines, and working in awkward postures. Interestingly, 8% of the population were exposed to at least two of these three factors, and an additional 3% were exposed to all three.

The impact of work-relatedness is demonstrated by the elevated MSD rates for certain industries in workers' compensation data as well as the BLS data. For example, in the State of Washington workers' compensation system, the overall IR of work-related MSDs was 3.87/100 workers in 1992, 3.72 in 1993, and 3.52 in 1994. Work-related MSDs in this study were defined as injuries and illnesses involving sprains/strains, joint inflammation, low-back pain, and nerve-compression syndromes. Four industries had rates at least four times the 1992–94 average rate: wallboard installation (23.6/100 workers per year), temporary help-assembly (23.6), roofing (19.9), and moving companies (18) [Washington State Department of Labor and Industries 1996].

COST

The precise cost of occupational MSDs is not known. Estimates vary depending on the method used. A conservative estimate previously published by NIOSH is $13 billion annually [NIOSH 1996]. Others have estimated the cost at $20 billion annually [AFL-CIO 1997]. Regardless of the estimate used, the problem is large both in health and economic terms.

Work-related MSDs are a major component of the cost of work-related illness in the United States. The California Workers' Compensation Institute (a non-profit research institute) estimates that upper-extremity MSD claims by workers average $21,453 each [CWCI 1993]. Back pain is by far the most prevalent and costly MSD among U.S. industries today. Recent analysis of the 1988 Occupational Health Supplement of the National Health Interview Survey (an ongoing household-based survey) shows that the overall prevalence of self-reported back pain from repeated activities on the most recent job was 4.5%, or 4.75 million U.S. workers [Behrens et al. 1994]. The mean cost per case of compensable low-back pain was reported to be $8,321 in 1989 [Webster and Snook 1994b].

Webster and Snook [1994a] estimated that the mean compensation cost per case of upper-extremity, work-related MSD was $8,070 in 1993; the total U.S. compensable cost for upper extremity, work-related MSDs was $563 million in 1993. For example, the State of Washington averaged 44,648 work-related MSD claims, with an average total cost of $166.8 million/year for the period 1992–94. The State of Washington has a working population that is 2% that of the U.S. workforce. The compensable cost is limited to the medical expenses and indemnity costs (lost wages). When other expenses such as the full lost wages, lost production, cost of recruiting and training replacement workers, cost of rehabilitating the affected workers, etc. are considered, the total cost to the national economy becomes much greater.

DEFINING HEALTH OUTCOMES

Work-related MSDs are defined differently in different studies; thus, it is not surprising that controversy has arisen about the relative importance of various risk factors in the etiology of these disorders. Some investigators restrict themselves to case definitions based on clinical pathology, some to the presence of symptoms, some to “objectively” demonstrable pathological processes, and some to work disability (such as lost work-time status).

The most common health outcome has been the occurrence of pain, which is assumed to be the precursor of more severe disease [Riihimäki 1995] or (as in the case of back pain) the disorder itself. Different MSD health outcomes have been assessed by investigators depending on the particular concern or nature of the study. The specific health outcomes studied vary depending on (a) the purpose of the study, (b) the composition of the study population, (c) the rarity or prevalence of the health outcome in the population, (d) the need to limit specific biases, and (e) the decisions of the investigators.

Different epidemiologic measures and time scales have also been used to quantify MSDs in groups of people (lifetime prevalence, period prevalence, point prevalence, IR, incidence ratio, etc.). Similarly, some studies have included chronic cases, whereas others have studied acute or subacute cases or both. Cross-sectional studies usually employ case definitions that take into account prevalent cases at different stages of the disease process—such as incipient disease or residual signs of a MSD that was once clinically apparent. Because of the multifactorial nature of MSDs, it has been necessary to look at a broad spectrum of outcome measures to assess the effects of these factors.

Certain authors have noted the scarcity of objective measures (including physical examination techniques) to define work-related MSDs, and the lack of standardized criteria for defining MSD cases. Such insufficiencies sometimes make study comparisons difficult [Gerr et al. 1991; Moore 1992; Frank et al. 1995; Riihimäki 1995; Hadler 1997]. It would be useful to have a concise pathophysiological definition and corresponding objective clinical test for each work-related MSD to translate the degree of tissue damage or dysfunction into an estimate of current or future disability and prognosis. Such definitions and tests do not yet exist. Clinically defined work-related MSDs often have no clearly delineated pathophysiological mechanisms for pathological processes. In cases where some criteria exist (such as carpal tunnel syndrome [CTS]), the standard of accuracy is relatively expensive, elaborate, and subject to interpretation. For example, the overlap between symptoms and presence of abnormalities in nerve conduction studies is not great [Stetson et al. 1993]; furthermore, abnormalities in nerve conduction studies cannot be reliably used to predict the future onset of CTS symptoms [Werner et al. 1997]. Thus, in the interest of feasibility, expense, and utility, simpler tests and less specific case definitions may have been used in some studies, thereby introducing some risk of misclassification for specific diagnostic entities.

For upper-extremity studies in this review, those with specific diagnostic criteria (including physical examination techniques) were given greater consideration than studies that used less-specific methods to define health outcomes. The review focused on observational studies whose health outcomes were based on the constellation of recognized symptoms and standard methods of clinical examination. For completeness, those epidemiologic studies that based their health outcomes on reported symptoms alone were also reviewed.

Therefore, this document focuses on the upper-extremity MSDs that have commonly used diagnostic symptoms and physical examination abnormality criteria. Specifically, these MSDs are (1) tension-neck syndrome, (2) rotator cuff tendinitis and impingement syndrome in the shoulder, (3) epicondylitis in the elbow, (4) CTS,
(5) wrist tendinitis, and (6) hand-arm vibration (HAV) syndrome. Generally, the physical examination techniques used to define these MSD cases of the upper extremity have been similar from study to study and involve standard examination techniques recognized by the American Academy of Orthopedic Surgeons, the American College of Physicians, or the International Labor Organization Musculoskeletal Task Force (thus increasing the reliability of comparisons between studies). Although physical examination techniques have not been commonly used in epidemiologic studies of low-back disorders, this document also reviews those epidemiologic studies that address low-back pain.

EXPOSURE MEASUREMENTS

Exposure measurements used in work-related MSD studies range from very crude measures (e.g., occupational title) to complex analytical techniques (e.g., spectral analysis of electrogoniometer measurements of joint motions). Some studies have relied on self-assessment of physical workload by the study subjects.

The accuracy of such self-assessment has been debated (both for under-estimation and over-estimation). Uhl et al. [1987] found that workers reported performing more physical work than observational data could support. Armstrong et al. [1989] found that workers can (on average) distinguish among levels of exposure, but workers' ratings may not correspond with objective measurements. Bernard et al. [1994] found that video display terminal (VDT) operators (those with and those without symptoms of work-related MSDs) reported that the average time they spent typing daily in the last year was twice that noted by independent observers in a single work day (although the 1-day observation period may have been insufficient to capture an average day of typing time). Similarly, Stubbs [1986] found large and significant differences between subjective and observed estimates of time spent working in specified postures. Fransson-Hall et al. [1995], on the other hand, found that workers tended to underestimate their exposures to contact stress of the hand compared with observation. This underestimation may be because workers tend to monitor discomfort from direct contact pressure—not the time spent with direct contact. Katz et al. [1996] found evidence of the validity of self-reported symptoms and functional status, and analysis of their data yielded evidence that variability in self-reports is not influenced by potential secondary gain.

As Riihimäki [1995] pointed out, it is difficult to assess current exposure, but it is even more difficult to assess cumulative past exposure retrospectively. Accurate retrospective data are usually not available; thus the exposure assessment is often based on self-reports, and the assessment may incur information bias.

A few studies have used observational methods to estimate exposures to workplace physical hazards more accurately and reliably. Because studies that directly observe or assess physical exposure factors are less likely to misclassify exposure status, these studies are given greater weight in this review.

Despite the noted limitations, occupations classified as "high-risk" in several studies share a number of workplace exposures associated with work-related MSDs. These workplace exposures occur in various combinations (singly, simultaneously, or sequentially) at different levels for different durations. These exposures have not been routinely broken down into task variables and quantified, with the mechanical or physiological loads defined and measured.

INFORMATION RETRIEVAL

This document examines scientific peer-reviewed epidemiologic journal articles, including recent publications addressing MSD risk factors, conference proceedings, and abstracts dealing with upper-extremity or back MSDs, recent textbooks, internally reviewed government reports or studies conducted by NIOSH, and other documents. Reports of epidemiologic studies were acquired using both CD-ROM and online commercial and governmental databases. Searches were carried out on computer-based bibliographic databases: Grateful Med® (which includes Medline® and Toxline®), NIOSHTIC® (a NIOSH database), and CIS (the International Labour Organization occupational health database). The search strategy included the following key terms: occupation, repetition, force, posture, vibration, cold, psychosocial, psychological, physiological, repetition strain injury, repetitive strain injury, epidemiology, etiology, cumulative trauma disorders, MSDs (neck, tension neck syndrome, shoulder, rotator cuff, elbow, epicondylitis, tendinitis, tenosynovitis, carpal tunnel, de Quervain's, nerve entrapment syndrome, vibration, back pain and sciatica, manual materials handling). Bibliographies of relevant articles were reviewed. Relevant foreign literature citations in English and included in the databases were included in this review along with literature from the personal files of the contributors. This search strategy identified more than 2,000 studies. Because of the focus on the epidemiology literature, a number of these studies that were laboratory-based or focused on MSDs from a biomechanical standpoint that dealt with clinical treatment of MSDs or other non-epidemiologic orientations were eliminated from further consideration for the present document. Over 600 studies were included in the detailed review process.

SELECTION OF STUDIES

The studies that were chosen for more detailed review specifically concerned the work-relatedness of MSDs, musculoskeletal problems of the neck, upper limbs, or back, and/or occupational and nonoccupational risk factors. The following inclusion criteria were used to select studies for the review:

Population: Studies were included if the exposed and referent populations were well defined.

Health outcome: Studies were included if they involved neck, upper-extremity, and low-back MSDs measured by well-defined, explicit criteria determined before the study. Studies whose primary outcomes were clinically relevant diagnostic entities generally had less misclassification and were likely to involve more severe cases. Studies whose primary outcomes were the reporting of symptoms generally had more misclassification of health status and a wider spectrum of severity.

Exposure: Studies were included if they evaluated exposure so that some inference could be drawn regarding repetition, force, extreme joint position, static loading or vibration, and lifting tasks. Studies in which exposure was measured or observed and recorded for the body part of concern were considered superior to studies that used self-reports or occupational/job titles as surrogates for exposure.

Study design: Population-based studies of MSDs, case-control studies, cross-sectional studies, longitudinal cohort studies, and case series were included.

METHODS FOR ANALYZING OR SYNTHESIZING STUDIES

The first step in the analytical process was to classify the epidemiologic studies by the following criteria:

1. The participation rate was $70%. This criterion limits the degree of selection bias in the study.

2. The health outcome was defined by symptoms and physical examination. This criterion reflects the preference of most reviewers to have health outcomes that are defined by objective criteria.

3. The investigators were blinded to health or exposure status when assessing health or exposure status. This criterion limits observer bias in classifying exposure or disease.

4. The joint under discussion was subjected to an independent exposure assessment, with characterization of the independent variable of interest (such as repetition or repetitive work). This criterion indicates whether the exposure assessment was conducted on the joint of interest and involved the type of exposure being examined— such as repetitive work, forceful exertion, extreme posture, or vibration. This criterion indicates whether the exposure was measured independently or in combination with other types of exposures. Exposure was also characterized by the method used to measure the level of exposure. Studies that used either direct observation or actual measurements of exposure were considered to have a more accurate exposure classification scheme, whereas studies that exclusively used job titles, interviews, or questionnaire information were assumed to have less accurate exposure information.

During review of the studies, the greatest qualitative weight was given to studies that had objective exposure assessments, high participation rates, physical examinations, and blinded assessment of health and exposure status. The chapters dealing with the different body regions—neck (including neck-shoulder), shoulder, elbow, hand/wrist, and low-back—summarize these characteristics for each study reviewed on the criteria table.

The second step of the analytical process was to divide the studies into those with statistically significant associations between exposures and health outcomes and those without statistically significant associations. The associations were then examined to determine whether they were likely to be substantially influenced by confounding or other selection bias (such as survivor bias or other epidemiologic pitfalls that might have a major influence on the interpretation of the findings). These include the absence of nonrespondent bias and comparability of study and comparison groups. There are also tables that summarize information about confounders and epidemiologic pitfalls for each study reviewed at the end of each body region chapter.

The third step of the analytical process was to review and summarize studies with regard to strength of association, consistency in association, temporal association, and exposure-response relationship. Each of these factors is discussed in greater detail in the next section (Criteria for Causality). Each study examined (those with negative, positive, or equivocal findings) contributed to the pool of data for determining the strength of work-relatedness using causal inference. The exposures examined for the neck and upper extremity were repetition, force, extreme posture, and segmental vibration. The exposures examined for the low back were heavy physical work, lifting, bending/twisting, whole-body vibration, and static postures.

Care should be taken when interpreting some study results regarding individual workplace factors of repetition, force, extreme or static postures, and vibration. As Kilbom [1994] stated, these factors occur simultaneously or during alternating tasks

within the same work, and their effects concur and interact. A single odds ratio (OR) for an individual risk factor may not accurately reflect the actual association, as not all of the studies derived ORs for simultaneously occurring factors. Thus these studies were not only viewed individually (taking into account good epidemiologic principles) but together as a body of evidence for making broader interpretations about epidemiologic causality. Many investigators did not examine each risk factor separately but selected study and comparison groups based on combinations of risk factors (such as workers in jobs involving high force and repetition compared with workers having no exposure to high force and repetition).

CRITERIA FOR CAUSALITY

No single epidemiologic study will fulfill all criteria for causality. However, the results of many epidemiologic studies can contribute to the evidence of causality in the relationship between workplace risk factors and MSDs. Rothman [1986] defined a cause as “an event, condition, or characteristic that plays an essential role in producing an occurrence of the disease.”

This document uses the following framework of criteria to evaluate evidence for causality. The framework was proposed by Hill [1966; 1971] and modified by Susser [1991] and Rothman [1986].

Strength of Association

The ORs and prevalence rate ratios (PRRs) from the reviewed studies were used to examine the strength of the association between exposure to workplace risk factors and MSDs, with the higher values indicating stronger association. The greater the magnitude of the relative risk (RR) or the

OR, the less likely the association is to be spurious [Cornfield et al. 1959; Bross 1966; Schlesselman 1978]. Weaker associations are more likely to be explained by undetected biases.

Debate is ongoing in the epidemiologic literature about studies with small sample sizes that find increased ORs or PRRs but have confidence intervals (CIs) that include 1.0. The question is whether such studies simply show no significant association or can be seen as useful estimates of associated risk. Nonetheless, it is useful to identify trends across such studies and consider whether they have valuable information after taking into account other epidemiologic principles. If the studies with and without significant findings both have similarly elevated ORs or PRRs, this information is useful in estimating the overall level of risk associated with exposure.

Consistency

Consistency refers to the repeated observation of an association in independent studies. Multiple studies yielding similar associations support the plausibility of a causal interpretation. Finding the same association with different and valid ways of measuring exposure and disease may show that the association is not dependent on measurement tools. Similar studies that yield diverse results weaken a causal interpretation.

Specificity of Effect or Association

This criterion refers to the association of a single risk factor with a specific health effect. We have not emphasized this criterion because of the different views of its utility in determining causality. If this criterion is interpreted to mean that a single stressor can be related to a specific outcome (e.g., that forceful exertion alone can be related to hand/wrist tendinitis) it becomes an important criterion for MSDs. However, this criterion can be interpreted and applied too simplistically. Schlesselman [1982] noted that the concept of specificity is that is generally too simplistic and that multiple causes and effects were more often the rule than the exception. Rothman [1986] referred to specificity of effect as “useless and misleading” as a criterion for causality.

Temporality

Temporality refers to documentation that the cause precedes the effect in time. Prospectively designed studies ensure that this criterion is strictly adhered to—that is, that exposure precedes adverse health outcome. But cross-sectional studies are not designed to allow strict adherence to this criterion because both exposure information and adverse health outcome are obtained at the same point in time.

Even though the cross-sectional study design precludes strict establishment of cause and effect, additional information can be used to make reasonable assumptions that exposure preceded the health effect—particularly when the relationship between physical exposures is measured by observation or direct measurement and by MSD-related health outcomes. If the exposure was directly measured or observed, it is also unlikely that the measurement was influenced by the presence or absence of the MSD in the employee. Rothman [1986] stated that it is important to realize that cause and effect in an epidemiologic study or epidemiologic data cannot be evaluated without making some assumptions (explicit or implicit) about the timing between exposure and disease. For example, from a cross-sectional study of hand/wrist tendinitis and highly forceful, repetitive jobs, a researcher can determine when exposure began from recorded work histories or from interviews. The researcher can also reasonably determine the time of tendinitis onset by interviews. Kleinbaum et al. [1982] said that in cross-sectional studies, risk factors and prognostic factors cannot be distinguished empirically *without additional information*.

With additional information (e.g., laboratory experiments or biomechanical findings), an investigator can deduce that the adverse health outcome followed exposure. For example, taking other confounders into account, it is unreasonable to deduce that persons with hand/wrist tendinitis are likely to seek employment in jobs that require highly forceful, repetitive exertion of the hand/wrist area.

Exposure-Response Relationship

The exposure-response relationship relates disease occurrence with the intensity, frequency, or duration of an exposure (or a combination of these factors). For example, if long-duration, forceful, repetitive work using the hands and wrists is associated with an increased prevalence of hand/wrist tendinitis, this association would tend to support a causal interpretation. Some have challenged the importance of physical factors as causal agents, but prospective studies have shown that reduced exposures result in a decreased disease [Bigos et al. 1991b]. In occupational health, important and effective preventive actions have been initiated without prospective demonstration that reduced exposure decreases the incidence of disease.

Coherence of Evidence

Coherence of evidence means that an association is consistent with the natural history and biology of disease. For example, an observed association between repetitive wrist motion and CTS (defined by nerve conduction criteria) must be supported by biological plausibility: repeated wrist movement can cause swelling of tissue in the carpal tunnel, resulting in injury to nerves. It is important to remember, however, that epidemiologic studies can identify new associations for further study.

CATEGORIES USED TO CLASSIFY THE EVIDENCE OF WORK-RELATEDNESS

After assessing the quality of individual epidemiologic studies, NIOSH investigators judged whether the evidence was strong enough to relate the risk factor to the MSD. In making this judgement, the investigators considered the criteria for causality. Studies which met all four evaluation criteria were given more weight than those which met at least one of the criteria.

The evidence of work-relatedness from epidemiologic studies is classified into one of the following categories: strong evidence of work-relatedness (+++), evidence of work-relatedness (++), inadequate evidence of work-relatedness (+/0), and evidence of no effect of work factors (-).

Strong Evidence of Work-Relatedness (+++)

A causal relationship is very likely between intense and/or long duration exposure to a specific risk factor(s) and an MSD when using the epidemiologic criteria of causality. A positive relationship has been observed between exposure to the risk factor and the MSD in at least several studies in which chance, bias, and confounding could be ruled out with reasonable confidence.

Evidence of Work-Relatedness (++)

Some convincing epidemiolgic evidence exists for a causal relationship using the epidemiologic criteria of causality for intense and/or long-duration exposure to a specific risk factor(s) and an MSD. A positive relationship has been observed between exposure to the risk factor and the MSD in studies in which chance, bias, and confounding are not the likely explanation.

Insufficient Evidence of Work-Relatedness (+/0)

The available studies are of insufficient quality, consistency, or statistical power to permit a conclusion regarding the presence or absence of a causal association. Some studies suggest a relationship to specific risk factors but chance, bias, or confounding may explain the association.

Evidence of No Effect of Work Factors (-)

Adequate studies consistently and strongly show that the specific risk factor is not related to MSDs.

SUMMARY

This document critically reviews the evidence regarding work-related risk factors and their relationship to MSDs of the neck, shoulder, elbow, hand/wrist, and low back. The document represents a first step in assessing the work-relatedness of MSDs. This step involves examination of relevant epidemiologic information to assess the strength of the available evidence that, under certain conditions of exposure, specific risk factors could increase the risk of MSDs or increase the likelihood of impairment or disability from MSDs. The second step would involve quantitative risk estimates that are beyond the purpose and scope of this document. This review of the epidemiologic literature may assist national and international authorities, academics, and policy makers in assessing risk and formulating decisions about future research or necessary preventive measures.

This document does not necessarily cite all of the literature on a particular MSD. Included are articles considered relevant by NIOSH investigators and internal and external reviewers of the draft document. Only reports that have been published or accepted for publication in the openly available scientific literature have been reviewed by the authors. In certain instances, they have included government agency reports that have undergone peer review and are widely available.

DESCRIPTION OF TABLES, FIGURES, AND APPENDICES

In each chapter on neck, shoulder, elbow, hand/wrist, and low back disorders, there are tables summarizing the risk indicators and epidemiologic criteria used in examining studies relevant to each body part. For each of these criteria tables there are corresponding figures which depict ORs, PRRs, or IRs, along with their associated CIs, if available.

In a separate table for each chapter, more extensive descriptions of studies, whether or not they contributed to decisions regarding causal inference, are provided for each body part. These tables include information from each study about their design, population, outcome, and exposure measures, as well as reported MSD prevalence. Some studies are included in the tables that may not be mentioned in the text. These additional studies are for information purposes only.

Appendix A, *Epidemiologic Review*, is a brief primer on occupational epidemiologic methods. Appendix B, *Individual Factors Associated with Work-Related Mus-culoskeletal Disorders (MSDs)*, discusses individual factors (age, gender, etc.) and their association with work-related MSDs. Appendix C, *Summary Tables*, provides a concise overview of the studies reviewed relative to the evaluation criteria, risk factors addressed, and other issues.

CHAPTER 2
Neck Musculoskeletal Disorders: Evidence for Work-Relatedness

SUMMARY

Over 40 epidemiologic studies have examined physical workplace factors and their relationship to neck and neck/shoulder musculoskeletal disorders (MSDs). Among these studies are those which fulfill rigorous epidemiologic criteria and appropriately address important issues so that causal inferences can be made. The majority of studies involved working groups with a combination of interacting work factors, but certain studies assessed specific work factors. Each of the studies we examined (those with negative, positive, or equivocal findings) contributed to the overall pool of data for us to use in assessing the strength of the work-relatedness using causal inference.

There is **evidence** for a causal relationship between highly repetitive work and neck and neck/shoulder MSDs. Most of the epidemiologic studies reviewed defined “repetitive work” for the neck as work activities which involve continuous arm or hand movements which affect the neck/shoulder musculature and generate loads on the neck/shoulder area; fewer studies examined relationships based on actual repetitive neck movements. The two studies which measured repetitive neck movements by measuring head position (using frequency and duration of movements) fulfilled the most stringent epidemiologic criteria, showing strong associations with neck/shoulder MSDs. In those studies defining repetitive work involving continuous arm or hand movements affecting the neck/shoulder, nine studies were statistically significant and had odds ratios (ORs) greater than 3.0.; eight studies fulfilled all the epidemiologic criteria except the exposure criteria, and measured repetition for the hand/wrist and not for the neck. Of these, three were statistically significant and had ORs greater than 3, five had nonsignificant ORs, all under 2.0.

There is also **evidence** for forceful exertion and the occurrence of neck MSDs in the epidemiologic literature. Most of the epidemiologic studies reviewed defined “forceful work” for the neck/shoulder as work activities which involve forceful arm or hand movements, which generate loads to the neck/shoulder area; no study examined a relationship based on actual forceful neck movements. Of the 17 studies addressing force as one of the exposure factors, five studies found statistically significant associations, but did not derive ORs; two studies found ORs greater than 3.0, seven studies from 1 to 3.0, and two studies with ORs less than 1.0. Many of the studies relating measured force (as workload, etc.) to MSDs are in the biomechanical and ergonomic literature.

There is **strong evidence** that working groups with high levels of static contraction, prolonged static loads, or extreme working postures involving the neck/shoulder muscles are at increased risk for neck/shoulder MSDs. Consistently high ORs were found (twelve statistically significant studies with ORs over 3.0) providing evidence linking tension-neck syndrome with static postures or static loads.

The epidemiologic data were **insufficient** to provide support for the relationship of vibration to neck disorders. At this time, further studies must be done before a decision regarding causal inference is made. The few prospective studies which have included interventions to decrease workplace exposures that include decreasing repetitive work and less extreme working postures showed a decrease in the incidence of neck MSDs and an improvement in symptoms among affected workers. The data on intervention provide additional evidence that these disorders are related to workplace risk factors.

INTRODUCTION

Studies from the United States have generally classified neck disorders separately from shoulder disorders when evaluating work-related risk factors. Scandinavian studies examining work-related factors, on the other hand, have often combined neck and shoulder MSDs into one health outcome variable. This was based on the concept that several muscles act on both the shoulder girdle and the upper spine together. We have divided our reviews of the neck and shoulder MSDs into two chapters: Chapter 2 addresses neck and neck/shoulder MSDs and Chapter 3 addresses shoulder MSDs.

Our discussion of the evidence for work-relatedness of the neck will include criteria Tables 2-1 through 2-6 and Figures 2-1 through 2-6. Shoulder MSDs will be discussed in the next chapter.

Epidemiologic studies have defined neck MSDs in one of two ways: (a) by symptoms occurring in the neck (usually with regard to a specific duration, frequency, or intensity), or (b) by using both symptoms and physical examination findings.

The prevalence of reported MSDs is generally lower when they are defined using both symptoms and physical examination results than when defined using symptoms alone. For example, the prevalence rate of tension neck syndrome (TNS) among male industrial workers in the United States was reported to be 4.9% from interview data and 1.4% when case definitions included physical exam findings [Hagberg and Wegman 1987]. The percent of work-related MSD cases defined by physical examination findings to those defined solely by symptoms has ranged from approximately 50% (Silverstein et al. [1987]; Blåder et al. [1991]; Bernard et al. [1993]; Hales et al. 1994]) to about 85% (Andersen and Gaardboe [1993b]). Forty-seven of the listed studies referenced included physical examination findings in their health outcome assessment criteria.

Many of the neck and neck/shoulder MSD studies referenced in the tables were part of larger studies that inquired about musculoskeletal symptoms and physical findings in multiple body sites. In most of these studies, there were no separate ergonomic exposure observations or measurements made that pertained to the neck region (e.g., there were no neck posture observations, neck angle measurements, neck work-load assessment, trapezius electromyographic testing, etc.). In these studies, the primary interest and measurement strategies focused on the hand and wrist region (e.g., Kuorinka and Koskinen [1979]; Ohlsson et al. [1989]; Hales et al. [1989]; Kiken et al. [1990]; Baron et al. [1991]). In the studies, workers were categorized only by hand/wrist exposures. Hand/wrist categorization will not reflect exposures of the neck region (or other musculoskeletal sites). For example, workers who may have frequent and rapid awkward postures of the neck but less frequent or extreme postures of the hand and wrist region may be misclassified as low risk if classification depends only on hand/wrist exposure. In general, we have given these studies less weight because of a significant potential for misclassification.

The text of this section on neck and neck/shoulder MSDs is organized by work-

related exposure factor. The discussion within each factor is organized according to the criteria for evaluating evidence for work-relatedness in epidemiologic studies using the strength of association, the consistency of association, temporal relationships, exposure-response relationship, and coherence of evidence. Conclusions are presented with respect to neck and neck/shoulder MSDs as a single disorder for each exposure factor. Summary information relevant to the criteria used to evaluate study quality is presented in Tables 2-1 through
2-6. A more extensive summary, which includes information on health outcome, covariates, and exposure measures, is presented at the end of this chapter.

Studies Included in Neck MSDs Tables

Forty-six epidemiologic studies dealing with neck MSDs and 23 dealing with neck/shoulder MSDs appear in the summary tables. Of the studies, 38 were cross-sectional, 2 were case-control studies, and 6 were prospective studies. Among all the studies pertaining to the neck or neck/shoulder area, 35 had participation rates of over 70%, 3 had less than 70%, and 8 did not report their participation rates.

REPETITION

Definition of Repetition for Neck and Neck/Shoulder MSDs

For our review of the neck or neck/shoulder region, we chose those epidemiologic studies that examined repetition or repetitive work activities and MSDs. Studies generally address repetition as cyclical work activities that involved either: (1) repetitive neck movements (e.g., the frequency of different head positions during a cycle), or

(2) repeated arm or shoulder motions that generate loads to the neck/shoulder area (e.g., trapezius muscle). Most of the studies that examined repetition or repetitive work as a potential risk factor for neck or neck/shoulder MSDs had several concurrent or interacting physical workplace factors that were being evaluated. Therefore, repetitive work was not necessarily considered the primary exposure factor but was considered along with the other work factors.

Studies Reporting on the Association of Repetition as a Work Factor for Neck and Neck/Shoulder MSDs

Either the risk factor “repetition” or “repetitive work” was included in 26 studies as a factor for selection of the study population in their examination of neck and neck/shoulder MSDs in the workplace. However, only a handful of these studies examined repetitive movements of the neck. Few of these studies observed or measured: (a) the frequency or duration of tasks pertaining to the neck, (b) the ratio of work-time-to-recovery time for neck or neck/shoulder involvement, or (c) the percentage of the workday spent on repetitive activities involving the neck. Instead, studies tended to compare and contrast the prevalences of neck symptoms and/or physical findings in workers in occupations requiring a combination of forceful, repetitive movements and extreme postures of the upper extremities (mainly of the hand/wrist) to workers in occupations without those requirements.

Twenty studies that mentioned repetitive work or repetitive movements found a statistically significant positive association between repetition and neck or neck/shoulder MSDs; 6 others had non-significant findings (Tables 2-1 and 2-2, Figures 2-1 and 2-2). In terms of magnitude of the association, 11 studies had ORs greater than 3.0, 11 had ORs between 1.0 and 3.0, and none had an OR less than 1.0. Four studies did not report their results in terms of ORs or Prevalence Rate Ratio (PRRs), although all of these found significant associations ($p<0.05$).

Studies Meeting the Four Evaluation Criteria

Of the 27 investigations (see Tables 2-1 and 2-2), 2 fulfilled all four evaluation criteria outlined earlier in the introduction section [Ohlsson et al. 1995; Jonsson et al. 1988]. Only the Ohlsson study reported ORs. The investigations assessed repetitive work as an independent variable in terms of frequency and duration of neck movements.

In the cross-sectional study by Ohlsson et al. [1995], female industrial assembly-line workers exposed to repetitive tasks with short (<30 seconds) cycles were compared to 2 referent groups: 68 former assembly workers and 64 other workers with no repetitive exposure at their current jobs. Industrial workers had to perform tasks with a posture requiring an intermittently flexed neck and elevated arms, which were abducted intermittently. Workers and referents reported neck/shoulder symptom(s) and had physical exams performed by a single examiner. The examiner was blinded to exposure status but not completely to group status. Ergonomic exposure assessment was extensive. It included videotaping, observation, and analysis of postures, including measurements of critical angles (15E and 30E) of flexion of the neck. Two independent readers determined frequency, duration, and critical angles of movement for each variable by taking the average of the two readings. Weekly working time, work rotation, patterns of breaks, and individual performance rate (piece rate) were recorded and used in the analysis. The study controlled for age, gender (only females were included), and psychosocial variables (“tendency for stress” and “worry”).

The other study that fulfilled the four criteria concerned a 3-year prospective study written up in a series of articles by Kilbom et al. [1986], Kilbom and Persson [1987], and Jonsson et al. 1988]. Female electronic workers in highly repetitive tasks with static postural loads to the neck and shoulder areas were followed over a 3-year period. In the second year, some of the employees had workplace interventions that decreased the number of repetitive tasks involving extreme neck and shoulder postures, while others continued to work at unaltered tasks. Three separate physical exams were carried out at yearly intervals, the first one initially assessing tenderness on palpation and pain or restriction with active and passive movements. Ergonomic assessments occurred at the outset of the study and included video analysis of postures and movements of the head, shoulder, and upper arm. The evaluation recorded work-cycle time and number of cycles per hour; time at rest for the arm, shoulder, and head; total number of rest periods; and average and total duration per work cycle and hour. (The method was designed to study short-cycle repetitive work under visual control.) The mean number of neck forward flexions >20E per hour was 728 (standard deviation [s.d.] 365) in the initial 96 workers. The participation rate of the study was 72% after 3 years; the investigators analyzed several variables separately for dropouts and found no significant differences with regards to medical status, physiologic capacity, working technique, or work history. The investigators performed step-wise logistic regression with deterioration of disorders or remaining healthy in the different locations (neck and neck/shoulder) as the two dependent variables. Age, muscle strength, job satisfaction, and high productivity were included in the logistic regression analyses of these studies. Video analysis and observation were used to assess repetitive exposure on all subjects, using work cycle time, number of cycles per hour, as well as number of neck flexions per hour as criteria. Work cycle time varied between 4.6 and 9.1 min, with a mean value of 6.6 min.

Strength of Association for Repetition

In the Ohlsson et al. [1995] study, the OR for the association between repetitive work related to the neck and any neck/shoulder diagnoses was 4.6; for a diagnosis of tension neck syndrome, it was 3.6.

For the cohort study carried out by Kilbom et al. [1986], at the 2-year followup, the number of neck flexions per hour appeared as a strong predictor for deterioration to severe disorders of the neck. Improvement to a "healthy status" classification from Year I to Year II was seen with reallocating workers to more varied work tasks (which required a reorganization of monotonous and repetitive work tasks). The new tasks were characterized as more dynamic and varied and included only occasional sitting tasks, caretaking work, surveillance of machinery, or assembling of bigger and heavier equipment. The article documenting the last phase of the cohort study by Jonsson et al. [1988] did not specifically address the neck but broadened the health outcome definition to include the neck/shoulder area and the rest of the upper extremity using "cervicobrachial region" as the health outcome of interest. A significant association between deterioration of health status of the cervicobrachial region between Year II and Year III of the study and "work cycle, total time" at the $p<0.05$ level was found (ORs were not given).

Studies Meeting at Least One of the Four Criteria—Strength of Association

Of the studies that found significant ORs over 3.0 but did not mention or fulfill all of the criteria, almost all focused on working groups with a combination of repetitive and forceful work and compared them to either population referents or groups in occupations with lower exposure. Almost all were cross-sectional surveys. These studies used health outcomes from symptom surveys and self-reported workplace exposure (no direct observations) and either compared symptomatic workers (neck MSD cases) to asymptomatic workers in the same workforce (e.g., Yu and Wong [1996]; Bergqvist et al. [1995a]; Schibye et al. [1995]; Hünting et al. [1981]) or in other occupations (e.g., Liss et al. [1995]; Andersen and Gaardboe [1993b]; Milerad and Ekenvall [1990]; Onishi et al. [1976]). Onishi et al. [1976] found significant differences in neck/shoulder MSDs (OR 3.8) between groups involved in repetitive upper limb operations and office workers. They found workers involved in repetitive activity had 10% to 30% maximum voluntary contraction (MVC) of the trapezius muscle. They concluded that habitual neck or shoulder muscle fatigue is

caused by repetitive tasks that result in localized tenderness and may be a precursor to chronic MSDs.

Andersen and Gaardboe [1993a] used a cross-sectional design to compare sewing machine operators with a random sample of women from the general population of the same region. A neck case required a strict predetermined symptom and physical examination definition. Exposure was assessed through observation and categorization of jobs, based on the authors' experience and judgements. However, the main interest for exposure assessment was duration of exposure as a sewing machine operator. Statistical modeling controlled for age, having children, not doing leisure exercise, smoking, and socioeconomic status found a significant trend for "neck/shoulder syndrome" in relation to years of exposure as a sewing machine operator, with ORs from 3.2 to 36.74. The OR for the lowest exposure category, 0-7 years, was not statistically significant, although the higher exposure levels were. For this study, the exposure classification scheme does not allow separation of the effects of repetition from those of force, and there was no precise measure of repetitiveness.

Baron et al. [1991] studied neck MSDs in 124 grocery store checkers and 157 other grocery store workers who were not checkers. The neck MSD case definition met predetermined symptom and physical exam criteria. Physical examinations had higher participation rates among the checkers (85%) than among the referents (55%). Telephone interviews to non-checkers resulted in questionnaire completion by 85% of the non-checkers. The OR for neck disorders among checkers was 2.0 (95% confidence interval [CI] 0.6–6.7), in a model that included age, hobbies, second jobs, systemic disease, and obesity.

Bergqvist et al. [1995a] carried out a study comparing office workers using video display terminals (VDTs) to those who did not. A physiotherapist's diagnosis of tension-neck syndrome was used to define a case. Exposure assessment was based on both self-reports and the investigators' observation of work postures, movements, and measurements of heights of work-station equipment in conjunction with the user. Statistical modeling included several individual factors, organizational factors, and ergonomic factors. For "tension neck" syndrome, no factor related to repetitive work was found to be significantly related.

Blåder et al. [1991] surveyed 199 sewing machine operators from 4 plants. Of the 155 who reported shoulder or neck pain, 131 were examined. Exposure assessment was by questionnaire and addressed employment duration and hours per week. Authors stated that the study involved a control group and took into account psychosocial factors, but the results were not included in the article. Both employment duration and working more than 30 hours per week were found to be statistically significant at the $p<0.05$ levels. For this study, the exposure as duration of work (per week and per years) does not allow separation of the effects of repetition from those of force. There was no direct measure of repetitiveness.

Ekberg et al. [1994] carried out a case-control study involving cases from a semi-rural community in southern Sweden who had consulted a community physician for MSDs of the neck, shoulder, arm, or upper thorax.

Cases had to have been ill immediately prior to physician visit and

have been on sick leave less than 4 weeks. Cases were excluded for trauma, infectious causes, accident, malignancy, rheumatic disease, abuse, or pregnancy. Controls were randomly selected from the Swedish insurance registry. Exposure was obtained by questionnaire. The analysis showed that for neck disorders with precise repetitive movements the OR was 3.8 for medium exposure and 15.6 for high exposure comparing jobs with low force and low repetition. Gender, immigrant status, work pace, and current smoking were also analyzed in the logistic model.

Ekberg et al. [1995] surveyed 637 Swedish residents for the presence of neck symptoms in the past six months. Exposure was based on questionnaire responses. Twenty questionnaire items on physical work conditions were factor analyzed. Age, smoking, exercise habits, and family situation with preschool children were not significantly associated with symptoms. Repetitive movements demanding precision was found to have an OR of 1.2 for neck pain.

Hales and Fine [1989] compared 89 female workers in 7 high exposure jobs to 25 female poultry workers in low exposure jobs employed in poultry processing. Neck case definition required symptoms and physical examination findings that met predetermined criteria. Exposure assessment was based on hand/wrist assessment of forceful and repetitive jobs. No assessment of neck repetition was performed. Twelve percent of workers in high risk jobs versus none in low risk jobs were found to have neck MSDS.

In a study of VDT users in a range of jobs (data entry to "conversational" VDT use), Hünting et al. [1981] used a case definition requiring symptoms and physical exams and an extensive exposure assessment using questionnaire, observation, and measurements of workstations, and body posture measurements using a prescribed method. Data entry terminal users, whose tasks required more extensive repetitive work than traditional office workers, found an OR of 9.9 with the comparison. There were no adjustments for confounders in this analysis.

Kamwendo et al. [1991] compared 420 medical secretaries with frequent, significant neck pain to those with few episodes based on questionnaire responses. Exposure was also questionnaire based. The analysis was controlled for age and length of employment. A surrogate for repetitive work consisted of hours sitting or working with office machines with high exposure equal to 5 hrs or more/day.

Kiken et al. [1990] also studied poultry workers at two plants with exposure to highly forceful, highly repetitive jobs and compared them to other poultry workers with less exposure. Neck case definition required symptoms and physical examination findings that met predetermined criteria. Exposure assessment was based on hand/wrist assessment of forceful and repetitive jobs. No assessment of neck repetition was performed. Job turnover was around 50% at plant 1 and 70% at plant 2 making survivor bias a strong possibility.

Kuorinka and Koskinen [1979] studied occupational rheumatic diseases and upper limb strain among 93 scissor makers and compared them to the same group of department store assistants (n=143) that Luopajärvi et al. [1979] used as a comparison group. Temporary workers and

those with recent trauma were excluded from the scissor makers group. Exposure assessment included videotape analysis of scissor maker tasks, however exposure assessed for the hand and wrist region and not the neck. No formal exposure assessment was conducted on the shop assistants. Health assessment involved an interview and physical examination by a physiotherapist following a standard protocol. Diagnoses of tension neck syndrome were determined using predetermined criteria [Waris et al. 1979]. In problem cases, orthopedic and physiatric teams determined case status. It is unclear whether cashiers were excluded from the comparison group in this study as they were in the Luopajärvi et al. [1979] study. The study group was 99% female.

Luopajärvi et al. [1979] compared the prevalence of neck/shoulder disorders among 152 female assembly line packers in a food production factory to 133 female shop assistants in a department store. Exposure to repetitive work, awkward hand/arm postures, and static work was assessed by observation and videotape analysis of factory workers. No formal exposure assessment was conducted on the department store workers; their job tasks were described as variable. Cashiers were excluded, presumably because their work was repetitive. No formal assessment occurred for neck/shoulder repetition. The health assessment consisted of interviews and physical examinations conducted by a physiotherapist, and diagnoses of tension neck syndrome were later determined by medical specialists using these findings and predetermined criteria (95% CI 2.63–6.49). Age, hobbies, and housework were considered in the analysis.

Milerad and Ekenvall [1990] compared the self-reported neck and neck/shoulder symptoms between dentists and pharmacists. Dentists had been considered the high risk group because of awkward postures and repetitive use of small handtools. Exposure was based on self-reports. The authors examined several covariates and stratified by gender for their analysis. No difference between groups in leisure time, smoking, systemic disease, and exposure to vibration.

Ohlsson et al. [1989] studied 148 electrical equipment and automobile assemblers, 76 former female assembly workers who quit within 4 years and compared these two groups to 60 randomly sampled females from the general population. A case was determined by questionnaire; exposure was based on job categorization and questionnaire responses. Repetitive exposure was based upon the number of items completed per hour. The work pace was divided into four classes: (1) Slow: <100 items/hr; (2) Medium: 100 to 199 items/hr; (3) Fast: 200 to 700 items/hr; (4) Very Fast: >700 items/hour. The OR increased with increasing work pace, except at very high paces, where there was a decrease. This was attributed to "selective quitting of subjects with complaints, only the healthiest being left in the assembly work."

Onishi et al. [1976] compared several groups of workers with varying exposure to repetitive tasks. Health outcome was based on symptoms of shoulder stiffness, dullness, pain, numbness; pressure measured by strain transducer at which a subject felt pain; and a physical exam. Observation and measurements of some job tasks, including some measures of repetition, were performed then job categorization was done. Based on job categorization and job analysis, and taking into account shift length, activities, number of breaks, repetitive movements of the hands, arm manipulations, and length of employment, there was not a difference between workers with tenderness threshold above 1.5 kg/cm² and those below with respect to age, height, weight, skinfold thickness, grip strength, upper arm abduction strength, and back muscle strength.

Punnett et al. [1985] compared neck/shoulder MSDs based on symptom reporting alone in 162 women garment workers and 76 women hospital workers such as nurses, laboratory technicians, and laundry workers. There was a low participation rate among the hospital workers. Eighty-six percent of the garment workers were sewing machine operators and finishers (sewing and trimming by hand). The sewing machine operators were described as using highly repetitive, low force wrist and finger motions, while the finishers had shoulder and elbow motions as well. The exposed garment workers likely had more repetitive jobs than most of the hospital workers. The neck/shoulder cases were found to lift both the "typical" and "heaviest" loads with greater frequency than non-cases.

Sakakibara et al. [1995] found among orchard workers that neck shoulder MSDs based on symptom and physical findings were significantly higher when performing pear bagging than when apple bagging. Exposure was based on measurements of specific angles of the neck and shoulder and job tasks in a representative worker. ORs were not derived in this study. Confounders were not checked for in this study.

Sakakibara et al. [1987] did not include physical exam findings in the case definition of neck and neck/shoulder MSDs when comparing workers bagging pears versus apples. Exposure was again based on measurements of job tasks by a representative worker.

Schibye et al. [1995] followed up 303 sewing machine operators at nine factories representing different technology levels who completed a questionnaire in 1985. In April 1991, 241 of 279 traced workers responded to the same 1985 questionnaire. Operators still working were compared to those who moved to other employment in 1991. Exposure was assessed through a questionnaire asking type of machine operated, work organization factors, workplace design factors, units produced per day, the payment system, and the duration of employment as a sewing machine operator. Although the authors state that the analysis did not show that neck symptoms among workers who had worked as a sewing machine operator to be significantly related to exposure, exposure time, or age, there was a significant drop-out rate of those above 35 years.

Rossignol et al. [1987] chose 38 random sites from Massachusetts workers with more than 50 employees, and selected 191 workers from computer and data processing services, and public utilities and the Commonwealth Government. Subjects were selected after the observation of the worksite. A self-administered questionnaire case definition was used for neck MSD. Exposure was also based upon self-reports of number of hours worked each day with a keyboard machine with a VDT. Analysis controlled for the following confounding factors: age, cigarette smoking, industry, and educational VDT training.

Yu and Wong [1996] chose to compare 90 data entry, data processing, and computer programmers from an International Bank in Hong Kong and 61 infrequent users of VDTs. Both neck MSD case definition and exposure assessment were based on symptom data. Analysis controlled for "age and gender, and other covariates" (as stated in the paper). For frequent VDT use an OR of 28.9 was found.

Kuorinka and Koskinen [1979] found a significant difference in neck MSDs between scissor makers (an occupation chosen for study because of its assembly-line repetitive hand tasks) and shop assistants (non-stereotypic, non-repetitive jobs) with an OR of 4.1. In the same study, comparing the different stereotypic, repetitive jobs in scissor-making, those in short-cycled tasks (2–9.5 sec) had no significantly different prevalence of neck disorders than workers in longer-cycled tasks (7.3–26 sec) (OR 1.6, 95% CI 0.7– 3.8). It is important to note that both the longer-cycled tasks and short-cycled tasks in Kuorinka's study would have been classified as "highly repetitive" in most other ergonomic studies [Silverstein et al. 1987; Chiang et al. 1993; Viikari-Juntura et al. 1991a; Kurppa et al. 1991]. When comparing two groups in which the level of repetitive exposure may not differ by much (in this case, where both groups have highly repetitive tasks), it is unlikely that one will find a significant difference because there is not enough variance between the exposures.

Three studies [Ekberg et al. 1994, 1995; Milerad and Ekenvall 1990] used health outcomes and exposure assessments based on self-reports and found significant associations between symptoms and repetitive work. The Ekberg studies specifically asked about "precise repetitive movements" in their questionnaire and controlled for confounders and effect modifiers (age, gender, having pre-school children) in their analyses. Milerad and Ekenvall [1990] compared dentists and pharmacists, stratified by gender, and found no association between neck or neck/shoulder MSDs with metabolic disease, smoking, leisure time, exposure, or vibration. Significant ORs of 2.0 to 2.6. for neck MSDs were reported for dentists compared to pharmacists.

Of those studies reporting no significant association between repetition and neck or neck/shoulder MSDs, none included exposure assessment or observations of the neck or neck/shoulder area that were both objective and independent of the hand/wrist. Several of these studies [Baron et al. 1991; Kiken et al. 1990; Hales et al. 1989; Ohlsson et al. 1989; Luopajärvi et al. 1979] categorized workers into high and low exposure groups based strictly on hand/wrist exposure and not arm, shoulder, or neck exposure. All of these studies reported ORs below 2.0.

In the study of VDT users by Bergqvist et al. [1995a], exposure was based on self-reports of "the presence of repeated work movements" for all work tasks and not specifically focused on the neck or neck/shoulder area. They found no significant association with neck/shoulder MSDs when the variable "repeated work movements" was analyzed in the logistic model alone, but found a significant relationship with a combination of variables: (1) workers wearing glasses, (2) who reported VDT use, and (3) VDT use for more than 20 hours/week. In this case, it was the combination of variables at higher levels of exposure (VDT use more than

20 hours per week) that was found to be statistically significant.

Temporal Relationship—Repetition and Neck/Shoulder MSDs

Of the prospective studies of neck MSDs that can be used to establish a temporal relationship between exposure to repetitive work and neck or neck/shoulder disorders, the study by Jonsson et al. [1988] fulfills all the four study criteria. Jonsson's study was a followup of the cohort studied by Kilbom et al. [1986], electronic workers who entered the study without MSDs. Exposure assessment pertaining specifically to the neck/shoulder area was completed three times over 3 years.

In the longitudinal study by Ohara et al. [1976], the authors attributed the increase in neck symptoms in cash register operators to the introduction of new electronic cash registers placed at unsuitable heights. They noted an increase in repetitiveness and an increase in awkward and static postures by cash register operators using the new registers. The authors reported a relationship between static loading and MSDs and found that a subsequent reduction in exposure to static loading resulted in less worker disability (sick leave).

Although temporality cannot be obtained from cross-sectional studies, several studies attempted to insure that disorders developed following the exposure being studied. In certain studies [Baron et al. 1991; Kiken et al. 1990; Hales et al. 1994; Hoekstra et al. 1994], the health outcome definition excluded persons reporting symptoms prior to the job or reporting acute injury thought to be unrelated to work, insuring that exposure preceded MSD occurrence. Other studies excluded participants with less than 6 months (or even longer) of job experience, thereby omitting from their study workers who may have developed their MSDs prior to working at the job of interest, or who had experienced discomfort or fatigue due to new activities or a "break-in period" at work. It is reasonable to assume that in those studies, given the exclusions required by the case definitions, the onset of exposure was prior to the onset of neck/shoulder MSDs in the majority of participants.

Consistency in Association for Repetition and Neck/Shoulder MSDs

In the studies fulfilling the four criteria [Ohlsson et al. 1995; Jonsson et al. 1988; Kilbom et al. 1986], significantly positive associations between neck MSDs and repetitive work were found. Many more studies involved workers in repetitive work from a range of industries (VDT workers, dentists, electronic assembly, sewing machine operators, etc.), comparing symptom prevalences to those in less repetitive jobs. There was also significant association between neck and neck/shoulder MSDs and jobs with repetitive tasks, with ORs between 1.6 and 5.9 [Onishi et al. 1976; Kuorinka and Koskinen 1979; Rossignol et al. 1987; Vihma et al. 1982; Kamwendo et al. 1991; Andersen and Gaardboe et al. 1993b; Ekberg et al. 1994, 1995; Schibye et al. 1995] indicating that workers exposed to higher levels of work risk factors have greater rates of neck and neck/shoulder symptoms. None of the studies that failed to find significant associations carried out exposure assessment of the neck or neck/shoulder.

Coherence of Evidence for Repetition

Studies outside the epidemiologic literature give supportive evidence that repetitive work is related to neck/shoulder disorders. Stevens et al. [1966] found that the neck injuries among fork-lift truck drivers were from repetitive, extreme head rotations needed for the operation of fork lift trucks and introduced the sideways-sitting driver forklift. Eklund et al. [1994] reported following up on a "sideways-sitting" forklift (in an unpublished study); these drivers experienced neck pain three times as often as other drivers on traditional forklifts—indicating that moderate head rotations during long periods of time can be more risky than short term and extensive head rotations. Nicholas [1990] reported in his discussion on pathophysiologic mechanisms of sports injuries that a low-load force with high repetition results in a gradual deterioration of tissue strength from strain to fatigue to deformation, with prefailure symptoms, such as pain on use, a common clinical sign of early inflammation from overuse.

Exposure-Response Relationship for Repetition

There were no studies reviewed that showed a clear dose-response relationship between repetition and neck and neck/shoulder MSDs.

Conclusions Regarding Repetition

The association between neck or neck/shoulder MSDs and repetitive work was found to be statistically significant in 19 studies using different epidemiologic approaches and under different circumstances of exposure. Twenty-seven studies found ORs above one; of these, 13 were above 3.0. Almost all the studies (6 of 8) with non-significant associations used hand/wrist exposure assessments for their analyses and did not conduct specific neck, shoulder, or upper extremity (apart from hand/wrist) exposure assessment. (Only one of the studies finding significant associations did so using hand/wrist exposure assessment.) The possibility of misclassification affecting the results must be a consideration.

FORCE

Definition of Force for Neck and Neck/Shoulder MSDs

For our review, we included studies that examined force or forceful work or heavy loads to the neck and neck/shoulder, or described exposure as strenuous work involving the upper extremity that generates loads to the trapezius muscles. Most of the studies that examined force or forceful work as a risk factor for neck/shoulder had several concurrent or interacting physical work load factors.

Force has generally been defined as: (1) either externally as a load or internally as a force on a body structure, or (2) a force magnitude expressed in newtons or pounds or as a proportion of an individual's strength capacity, that is, of a person's MVC, usually measured by EMG. Most studies that have dealt with force loading of the neck or stress generated on the neck structures are from biomechanical studies performed in the laboratory. These studies are not included in this document. In the epidemiologic studies reviewed, force is usually estimated by either questionnaire, biomechanical models, in terms of weight lifted, electromyographic activity, or the variable, " heavy physical workload."

Seventeen studies reported results on the association between force or forceful work (in combination with repetition) and neck and neck/shoulder MSDs. Of the 17 studies of force and neck MSDs, 11 found a statistically significant positive association between force and neck or neck/shoulder MSDs; six others had non-significant findings. In terms of magnitude of the association, two studies had ORs greater than 3.0, seven were between 1.0 and 3.0, and two were less than 1.0. Six studies did not report their results in terms of ORs or prevalence rate ratios (PRRs) but reported that the findings were statistically significant at the $p<0.05$ level.

Studies Meeting the Four Criteria for Force and Neck/Shoulder MSDs

There were no studies that met the four epidemiologic evaluation criteria for forceful exertion of the neck.

Studies Not Meeting the Four Criteria for Force and Neck/Shoulder MSDs

Åaras [1994] carried out a cohort study of four groups, 15 female assembly workers making telephone exchanges, 27 female VDT users, 25 female data entry operators, and 29 male VDT users. Case definition for neck MSD was based on self-reports. However, musculoskeletal sick leave per man-labor years was also used as an endpoint. For force estimate the load on the

trapezius was measured by electromyography (EMG).

Quantification of the muscle load was done by ranking the interval estimate (0.1 s) to produce an amplitude probability distribution function. Both the total duration and number of periods per minute when muscle activity was below 1% maximum voluntary contraction (MVC) were calculated. Post-intervention (which involved changes to the workstation, tools, and organization of work)—see Table 2-4 at the end of the chapter for further explanation, the mean static trapezius load in assemblers was reduced from 4.3% MVC to 1.4%, the mean static trapezius load in VDT users reduced from 2.7% MVC to 1.6% MVC (post-intervention). Sick leave also decreased considerably. Because so many interventions were involved in this study, it is not clear to what intervention changes the decrease in sick-leave per man-labor years might be attributed.

Bjelle et al. [1981] compared 13 workers of an industrial plant consecutively seen at a health clinic with acute, nontraumatic shoulder-neck pain not due to causative disease or malformation compared to 26 controls, matched on age, gender and place of work.

In another cohort study, Veiersted and Westgaard [1994] followed 30 female chocolate manufacturing workers, 17 of whom contracted trapezius myalgia within 6 to 51 weeks compared to those workers who did not. Diagnosis was based on both symptoms and physical exam. There were prospective interviews every 10 weeks to detect symptoms of muscle pain. Daily "pain diaries" were also kept by subjects.

Exposure assessment consisted of measured static muscle tension recorded by EMG. Interviews concerning exposure at work were also conducted prospectively every 10 weeks for 1 year. Only 55% of the subjects were retained during the full study; however, the 'drop-outs' were follow-up subjects and had no significant differences in static muscle tension compared to the participants.

Viikari-Juntura et al. [1994] , the third longitudinal study discussed under force and neck and neck/shoulder MSDs, used questionnaire to assess neck symptoms and based exposure on job category, comparing 688 machine operators, 553 carpenters, and 591 office workers. For the initial evaluation, observation of work sites were performed. In multivariate analysis occupation, age, and current smoking were significant predictors in change from no neck trouble to severe neck trouble (ORs were not given for logistic model.)

Wells et al. [1983] evaluated letter carriers with an increased load on the shoulder from a mailbag. Letter carriers were compared to gas meter readers (without heavy loads) and postal clerks. A telephone survey was used to obtain both symptoms and exposure. This analysis was adjusted for age, number of years on the job, quetelet (body mass) ratio and previous work experience.

Of the studies in the tables, five (that did not fulfill all the inclusion criteria) examined the risk factor, force, either as trapezius muscle load (using EMG), or as forceful work in combination with other risk factors [Aåras 1994; Wells et al. 1983; Onishi et al. 1976; Andersen and Gaardboe 1993a; Punnett 1991]. Wells et al. [1983] found a significant difference (p<0.05) in reported neck pain between letter carriers and postal clerks and attributed it to weight from carrying heavy mail bags on shoulder straps. In the Wells study, confounding due to age, number of years on the job, previous work experience, or quetelet ratios was ruled out. As noted above, Onishi et al. [1976] reported that the operations studied required continuous contraction of the trapezius muscle to sustain the arms, estimated to be about 10 to 30% of the maximum contraction of the trapezius. This level, 10 to 30% of the maximum contraction, was found by Tanii et al. [1972] to induce static fatigue significant enough to produce electromyographic changes. Hales et al. [1989] and Kuorinka and Koskinen [1979] reported statistically significant ORs (1.6 and 4.1, respectively) for the association between neck MSDs and high levels of force combined with high levels of repetition estimated for the hand/wrist areas. There were no separate force measurements for the neck area. Both studies controlled for age, gender, and length of employment in the current job. Two of the four studies that used estimated hand and wrist exposure measurement combinations of force and repetition (but carried out no neck, shoulder, or upper extremity exposure measurements) found non-significant associations between neck MSDs and force/repetition exposure [Baron et al. 1991; Kiken et al. 1990].

Temporal Relationship—Force and Neck/Shoulder MSDs

See temporal relationship above in Repetition and Neck/Shoulder MSDs.

Consistency in Association for Force and Neck/Shoulder MSDs

Both Kilbom et al. [1986] in their cross-sectional study and Jonsson et al. [1988] in their follow-up cohort studies found that "time spent in physically heavy work before the present employment" appeared as a strong risk factor for deterioration of health of the neck/shoulder area (specifically, the health outcome was for the cervicobrachial region in the Jonsson study). Jonsson et al. [1988] noted that the physical demands of the previous jobs had only been assessed at the initial interview and constituted a subjective estimate. However, the relationship was strengthened by the consistency of findings in the prospective and cross-sectional studies.

Coherence of Evidence for Force

There is coherence with the biological mechanisms proposed by Hagberg [1984] for occupational muscle-related disorders, such as tension neck syndrome. The first mechanism concerns stress on the trapezius and surrounding muscles of the neck from heavy physical exertion that causes rupture of the muscle's z-discs, and an outflow of metabolites from the muscle fibers, and activation of pain receptors through edema or other mechanisms. This temporary high, local stress involving eccentric contractions in the shoulders improves with time through a re-orientation of collagen in the muscles. This mechanism is offered as an explanation for MSDs in workers unaccustomed to the work. The second mechanism is from local decreased blood flow (ischemia), as seen in assembly workers whose tasks involved dynamic, frequent contractions above 10 to 20% of the MVC and few rest breaks. Reduced blood flow was found to be correlated with myalgia (muscle pain) and ragged red fibers in 17 patients with chronic myalgia thought to be associated with static load during repetitive assembly work [Larsson et al. 1990]. The third pathophysiologic mechanism for muscle pain deals with energy metabolism disturbance, caused by long-term static contractions of the muscles. Supporting this theory was a study finding a correlation between muscle tension and plasma myoglobin among patients with regional muscle tenderness and pain [Dammeskiold-Samsøe et al. 1982].

Other laboratory studies have examined muscle damage that may arise during static muscle contractions used to maintain static postures. Hägg et al. [1990] proposed that while maintaining static postures (that have low force levels), the same low-threshold motor units are contracted repeatedly for prolonged periods, during which time they work close to their maximal capacity. This may lead to injury of these units, despite the fact that the total workload is low. This hypothesis was recently supported by a longitudinal study by Veiersted et al. [1993] who investigated the number of rest-pauses during muscle fiber activity using EMG recording from neck and shoulder muscles. Among subjects performing machine-paced repetitive packing work, those with symptoms had fewer rest-pauses (0.9 versus 8.4 per minute) and a tendency toward shorter total duration of rest-pauses in the muscle fiber activity of their trapezius muscle when compared with those without symptoms. These mechanisms of decreased blood flow, increased metabolite concentration, and prolonged activation of certain small units at near maximum capacity may explain the chronic myofascial shoulder pain seen in workers performing repetitive assembly work with static loading of the trapezius muscles [Hagberg and Kvarnström 1984; Larsson et al. 1988].

Exposure-Response Relationship for Force

Åaras [1994] reported that by reducing static muscle loading (an indication of force measurement) through equipment changes among VDT users, as well as improving workplace organization, he was able to decrease the prevalence of neck pain, decrease the number of sick days taken, and cause a significant reduction in trapezius load measured by EMG in VDT operators.

Conclusions Regarding Force

There is **evidence** for forceful exertion and neck MSDs in the epidemiologic literature. Most of the epidemiologic studies reviewed defined “forceful work” for the neck/shoulder as work activities that involve forceful arm or hand movements that, in turn, generate the loads to the neck/shoulder area; no study examined a relationship based on actual forceful neck movements. Of the 17 studies addressing force as one of the exposure factors, 5 found statistically significant associations but did not derive ORs; 2 found ORs greater than 3.0, 7 found ORs from 1 to 3.0, and 2 studies showed ORs less than 1.0. Many of the studies regarding measured force (as workload, etc.) and MSDs are in the biomechanical and ergonomic literature.

POSTURE

Definition of Posture for Neck and Neck/Shoulder MSDs

We included those articles that mentioned neck or head postures, adverse or extreme head or neck postures, or static postures of the head and/or neck.

Studies Reporting on Posture as a Work Factor for Neck and Neck/Shoulder Musculoskeletal Disorders

We included 31 studies of the association between extreme or static posture and neck and neck/shoulder MSDs, including TNS. Studies usually focused on the different prevalences of neck symptoms and/or physical findings in workers in occupations or tasks requiring some combination of forceful, repetitive movements, and extreme or static postures of the upper extremity, and compared them to workers in occupations without those requirements.

Twenty-seven studies that considered extreme or static posture found a statistically significant positive association between posture and neck or neck/shoulder MSDs; three had non-significant findings (Table 2-1. Overall, in terms of magnitude of the association, looking at both significant and non-significant findings, 13 studies had estimations of risk (ORs or PRRs) greater than 3.0, 9 had risk estimates between 1 and 3, and none had an estimate less than 1.0. Eleven studies did not report their results in terms of ORs or PRRs; of these, all but one found a significant relationship.

Studies Meeting the Four Evaluation Criteria

Of the 31 studies evaluating neck postures and neck MSDs, the four investigations mentioned above [Ohlsson et al. 1995; Jonsson et al. 1988; Kilbom and Persson 1987; Kilbom et al. 1986] fulfilled the four evaluation criteria. Three of these studies [Jonsson et al. 1988; Kilbom et al. 1986; Kilbom and Persson 1987], dealt with the same cohort; female electronics workers followed for 3 successive years. These studies found significant association between posture variables and neck MSDs; however, none used methods that reported ORs.

Studies Not Meeting the Four Criteria for Posture and Neck/Shoulder MSDs

Bernard et al. [1993] carried out a cross-sectional study of 894 newspaper employees using a questionnaire survey for case definition based on frequency, duration, and intensity of symptoms in the neck. Exposure was based upon both questionnaire and job analysis. Time spent on the telephone was associated with an increased prevalence of neck MSDs, with a slightly elevated OR of 1.4. Analysis was controlled for age, gender, height, psychosocial factors, and medical conditions.

Kukkonen et al. [1983] compared 104 data entry operators with 57 female workers in varying office tasks. Neck MSD was based on pre-determined symptom and physical exam. Exposure was based on observation of posture, movements and working techniques, assessment of equipment, interview with workers and supervisors. An intervention consisting of adjustment of office furniture and equipment was carried out. The study group was given a short course of basic training on pertinent aspects of ergonomics. Four lessons on relaxation was given by means of exercises. There was no controlling of confounders. There was a significant decrease in tension neck syndrome among the cases involved in the intervention compared to those workers who had no change.

Linton and Kamwendo [1989] surveyed 22,180 employees undergoing screening examinations at their occupational health care service in Sweden. Neck cases defined from questionnaire responses as those persons reporting “yes” to having seen a health care professional for neck pain in the last year. Cases were compared to “non-cases” defined by outcome (neck pain). Exposure was based on questionnaire responses regarding heavy lifting, monotonous or assembly line work, sitting, uncomfortable work postures (bending and twisting), and vibration. The psychosocial work environment was also studied; the analysis was stratified for age and gender.

As part of a longitudinal study, Viikari-Juntura et al. [1994] studied 154 subjects from Helsinki, Finland that originally entered the study in 1955, and had repeated cross-sectional exams from 1961 to 1963. During that time, 1084 subjects underwent cross-sectional examination. In 1985, a questionnaire was sent to all subjects; 801 (74%) responded. Of the respondents, 180 lived in the Helsinki area. It was from this group that 162 responded. Eight were excluded due to illnesses. Outcome was based on questionnaire data for this study — because of small number of abnormal physical findings, the physical exam was eliminated from analysis. Exposure was also based on survey, asking the amount of work with hands overhead, work in forward bent position, and work in twisted or bent position. This analysis was controlled for physical and creative hobbies, with no interactions seen.

In a cross-sectional study of machine operators, carpenters were compared to office workers by Tola et al. [1988], who used a postal questionnaire to obtain both health outcome and exposure information. Analysis used “occupation” to examine relationships. Pain Drawing Diagrams were used to distinguish body areas. For the logistic regression model a 12 month prevalence of neck and shoulder symptoms on 8 days or more was used. The logistic regression models were adjusted for years working in an occupation and age.

Welch et al. [1995] examined 39 electricians at a screening convention using surveys to collect information on symptoms and exposures. The questionnaire included questions concerning the frequency of tasks performed, including the percent of time spent hanging duct work. The analysis did not control for confounders except for length of employment.

Strength of Association for Posture

Ohlsson et al.'s [1995] study, discussed previously, compared female industrial workers performing repetitive tasks to referents without such exposure and found significant associations ($p<0.05$) between (1) neck and neck/shoulder diagnoses with time spent in neck flexion, with critical angles greater than 15E; and (2) neck/shoulder diagnoses and time spent with upper arm abduction greater than 60E.

Kilbom et al. [1986], in the initial paper concerning the electronic workers, reported two findings: (1) that the more dynamic the working technique, the fewer neck symptoms experienced by electronic workers; and (2) that the greater the average time per work cycle spent in neck flexion, the greater the association with symptoms in the neck and neck/shoulder angle. A statistically significant association ($p<0.05$) was also obtained from the job analysis variables describing neck forward flexion and upper arm elevation and neck and neck/shoulder disorders. Jonsson et al. [1988], in the follow-up study, performed an analysis that grouped the different parts of the neck and upper extremity into a health outcome labeled “cervicobrachial disorder” (unlike the cross-sectional study by Kilbom et al. [1986] that used “neck” and shoulder”). They found that the relationships between MSDs and neck forward flexion, upper arm elevation, and cervicobrachial disorders weakened (compared with the results that Kilbom et al. [1986] had found), but that the results still remained statistically significant in some of the multifactorial analyses (no numerical results were reported). The most important finding, according to the authors, was that reallocation to more varied work tasks was a strong predictor of improvement over the second year. This change would have decreased static loading and increased the dynamic pattern of movements of the workers.

Of those studies not fulfilling the four criteria, results regarding extreme or static posture were similar to those of the studies which did fulfill them. Sakakibara et al. [1995] found a significant difference in the prevalence of neck MSDs when they examined orchard workers who picked and bagged pears and two months later picked and bagged apples. Exposure was assessed by job analysis and posture measurements of two representative workers. Arm and neck elevation was significantly greater for bagging pears (more than 90E for 75% of the time) than for bagging apples (less than 40% of the time). The same authors found similar results in 1987 when only the symptoms of orchard workers were studied. They found significant a positive association between posture and neck MSDs, reporting histograms (not ORs) in their article.

Although they did not mention the participation rates in their methods, Åaras [1994], Veiersted and Westgaard [1994], and Bjelle et al. [1981] found significant relationships between postures and neck MSDs (they fulfilled the other three criteria). Veiersted and Westgaard [1994] found an association between “perceived strenuous postures" and neck MSDs (OR 7.2), but found that these perceived postures were not reflected in any of the conventional EMG parameters (static, median or peak loads) measured in the participants. One explanation for these results may be information bias, if the data concerning perceived strenuous posture are from questionnaires. Another explanation may be that EMG testing results reflect parameters for a single day, whereas symptoms were asked about concerning the entire previous year.

Several studies that carried out no independent assessment of ergonomic factors, but relied on self-reported exposure found significant relationships between posture variables and neck disorders. Ekberg et al. [1994] found an OR of 4.8 for the variable "work with lifted arms," and an OR of 3.6 for "uncomfortable sitting position" and neck MSDs. Hales et al. [1994] found that "use of bifocals" (OR 3.8) in VDT users was significantly associated with neck MSDs; this variable was interpreted to be a surrogate for neck posture, as bifocals require either neck flexion or extension for eye accommodation when viewing a VDT screen. Bernard et al. [1994] reported that as workers' time spent on the telephone increased, so did the ORs for neck symptoms, and interpreted this variable as a surrogate for static posture requiring neck deviation to cradle the telephone receiver. Holmström et al. [1992] found that the odds of workers with neck MSDs reporting working with hands above their shoulders for greater than 4 hrs/day compared with those reporting less than 1 hr/day was 2.0, a statistically significant finding. Bergqvist et al. [1995a] reported an OR of 4.4 for workers using highly placed keyboards in their logistic modeling of neck MSDs. Kuorinka and Koskinen [1979] found an increased OR (4.1) of neck MSDs for scissor makers (chosen for their stereotypic, repetitive work using extreme postures) compared to shop assistants, although no quantitative measurements or observations of neck posture were reported. One study by Hünting et al. [1981] showed a fairly strong association (OR 4.9) with constrained postures and neck MSDs in those workers having neck flexion of more than 56E and an OR of 9.9 from the comparison of groups. Several articles with significant posture and neck MSD associations dealt with comparisons of workers in occupations chosen for higher observed combinations of exposure factors and compared them to workers with fewer observed exposure stressors: Viikari-Juntura et al. [1994], OR 3.9 to 4.2; Milerad and Ekenvall [1990], OR 2.6; and Wells et al. [1983], OR 2.57.

For those studies that did not find a significant relationship, 2 out of the 3 did not carry out observation or measurement (ergonomic assessment) of the neck or upper extremity postures. Ferguson [1976] stated that seven body dimensions were measured in the telephonists studied, but that neither discomfort nor aching were linked with any of these body postures. The article does not mention the body postures that were measured. Ferguson's conclusion, that "physical complaints in telephonists are probably due to static load on joints and muscles occasioned by the fixed forward bent position determined by visual, auditory

and manipulative tasks." Ferguson's data are contrary to the conclusions presented. These conclusions may then only be speculative.

Temporality for Extreme or Static Postures

The prospective study by Veiersted and Westgaard [1994] followed the development of trapezius myalgia among 30 female chocolate manufacturing workers. Seventeen workers developed the MSD within 6 to 51 weeks of starting work. Perceived strenuous postures on the assembly line were found to contribute to the disorders. Although retention of subjects was low (55%), the authors found that the “drop-outs” did not differ in exposure estimates and symptom reporting from those retained in the study. The prospective study of Viikari-Juntura et al. [1994] used self-reported symptoms and exposure defined by occupational status to find a temporal relationship between the development of severe and persistent severe neck pain and jobs involving dynamic work, static posture, and whole body vibration, as compared to office work.

Consistency in Association for Extreme or Static Postures and Neck/Shoulder MSDs

Of the 31 studies we reviewed reporting results on the association between specific or static posture and neck and neck/shoulder MSDs, 27 found statistically significant associations. There were many different studies reporting ORs of greater than 3.0 with CIs above 1, indicating that the effects were not explained by chance. Consistent associations were also found in those studies dealing with specific postures and neck MSDs across many industries, from fish workers [Ohlsson et al. 1995] to fruit pickers [Sakakibara et al. 1995], to assembly line workers [Jonsson et al. 1988], to garment workers [Vihma et al. 1982; Andersen and Gaardboe 1993a,b].

Coherence of Evidence for Extreme Or Static Postures

See section above under Coherence of Evidence for Force.

Exposure-Response Relationship for Specific or Static Postures

The study by Ohara et al. [1976], mentioned earlier, not only portrayed the multifactorial nature of neck and shoulder MSDs, but documented that an increase in specific and static postures by cash register operators using new registers placed on unsuitable counter heights increased symptoms in neck MSDs.

Several studies have suggested an exposure-response effect between increased level or duration of exposure and an increase in number of cases of neck MSDs. Burt et al. [1990], in their investigation at a major urban newspaper, found that an increase in the self-reported percentage of time spent typing at VDT keyboards was associated with a moderate increase in neck symptoms. (Job analysis found a significant relationship between independent observation of time spent typing and self-reported time) Keyboard time was considered by the authors to be a surrogate for time spent with the neck held in static postures with arms unsupported. Rossignol et al. [1987] found that the prevalence of neck symptoms among 1,545 clerical workers increased with the number of hours per day using VDTs. Knave et al. [1985] found that, among VDT operators, total daily working hours and time spent at the VDT screen were significant risk factors for neck pain. Andersen and Gaardboe [1993a,b] found an exposure-response relationship between persistent neck pain and years of being a sewing machine operator, controlling for age.

Conclusions Regarding Extreme or Static Postures

Overall, the strength of the association (OR ranging from about 1.6 [Vihma et al. 1982] to 7 [Veiersted and Westgaard 1994], dropping the outliers) between specific postures and neck MSDs was similar between studies using the most restrictive criteria and carrying out a prospective design and those that used symptom-based health outcome or self-reported exposures to static or specific postures and cross-sectional methods. We conclude that there is **strong evidence** for support of an association between static or specific postures and neck and neck/ shoulder MSDs based on strength of association criteria. A positive relationship has been observed between exposure to this risk factor and neck or neck/shoulder MSDs in studies where chance, bias, and confounding can be ruled out with reasonable confidence.

VIBRATION

No study of neck MSDs met the four criteria to address strength of association between vibration and neck MSDs and only one of the reviewed studies in the tables mentioned neck MSDs and vibration. Viikari-Juntura et al. [1994] selected study groups for their longitudinal study based on different work exposures. Machine operators exposed to static work and whole-body vibration were compared to carpenters exposed to dynamic physical work and presumably no vibration to see whether occupational status was related to neck MSDs. Results found that the OR for progressing from no neck pain to moderate to severe neck trouble was from 3.9 to 4.2; for operators compared to carpenters; a significant difference. No vibration measurements were performed in this study, and vibration was likely to be confounded by neck twisting and static loads.

Conclusions—Vibration and Neck or Neck/Shoulder MSDs

We conclude that there is **insufficient evidence** to support an association between vibration and neck or neck/shoulder MSDs based on strength-of-association criteria. Too few studies of neck or neck/shoulder MSDs have examined the relationship between exposure to vibration and to draw any conclusions about their relationship.

NECK OR NECK/SHOULDER MSDs AND THE ROLE OF CONFOUNDERS

As in many MSDs, prevalence of neck and neck/shoulder disorders tends to increase with age. Therefore, it is important that studies take into account when examining the strength of occupational versus non-occupational factors. Age and gender were the primary potential confounders that investigators addressed in many of the studies on neck and neck/shoulder MSDs (The tables at the end of the chapter list summaries of each of the articles and include which particular covariates or confounders were considered.) These were either dealt with by logistic regression modeling, as in the case of age (e.g., Andersen and Gaardboe [1993a]; Rossignol et al. [1987]; Tola et al. [1988]; Ohlsson et al. [1989]; Baron et al. [1991]), through matching of case subjects and referents (e.g., Vihma et al. [1982]), or through study of a single gender (e.g., Luopajärvi et al. [1979];

Hünting et al. [1994]), or stratifying by gender [Sakakibara et al. 1995]. Most studies performed univariate analysis prior to logistic regression to consider factors which needed to be introduced into the logistic models as confounders or covariates.

Almost all the studies we reviewed accounted for the confounders of age and gender. Many of the studies controlled for leisure exercises [Andersen and Gaardboe [1993a,b] smoking (Linton [1990]; Milerad and Ekenwall [1990]; Bergqvist et al. [1995a,b]; Viikari-Juntura et al. [1994]), medical conditions [Bernard et al. [1994]; Hales et al. [1994]). Reviewing the methods and results of these studies, the confounding factors do not account for the consistent relationship that is found with the work-related factors.

CONCLUSIONS

Interpreting association for individual workplace factors is difficult, as most epidemiologic studies of MSDs used populations selected because of multiple factors (such as forceful exertion and repetitive tasks). Unlike laboratory experiments, one cannot isolate exposure factors, nor alter some factors while keeping others constant to insure accuracy in examining, recording, and interpreting results. However, one can examine the body of epidemiologic evidence and infer relationships. There have been over 40 epidemiologic studies which have examined work factors and their relationship to neck and neck/shoulder MSDs. Many studies identified individuals in heavier industrial occupations and compared them to workers in light industry or office environments. Other studies identified a symptomatic group of workers, or those with symptoms and physical exam abnormalities, and compared them to asymptomatic workers at the same worksite, or to population referents, and looked for differences in exposure. These approaches, although quite different, by and large have chosen to focus on similar workplace risk factors. These include repetition, forceful exertions, and constrained or static postures, usually found in combination.

There is also reasonable **evidence** for a causal relationship between highly repetitive work and neck and neck/shoulder MSDs. Most of the epidemiologic studies reviewed defined "repetitive work" for the neck as work activities which involve continuous arm or hand movements which affect the neck/shoulder musculature and generate loads to the neck/shoulder area; fewer studies examined relationships based on actual repetitive neck movements. The two studies which measured repetitive neck movements by head position (using frequency and duration of movements), and fulfilled the four criteria, found strong associations with neck/shoulder MSDs. In those studies defining repetitive work as continuous arm or hand movements affecting the neck/shoulder, nine studies found statistically significant ORs greater than 3.0. Eight studies fulfilled all the criteria except for objective exposure assessment and measured repetition for the hand/wrist, not the neck. Of these, three had statistically significant ORs greater than 3, and five had non-significant ORs, all under 2.0.

There is reasonable **evidence** for forceful exertion and neck MSD found in the epidemiologic literature. Most of the epidemiologic studies reviewed defined "forceful work" for the neck/shoulder as work activities which involve forceful arm or hand movements which generate the loads to the neck/shoulder area; no study examined a relationships based on actual forceful neck movements. Of the 17 studies

addressing force as one of the exposure factors, five studies found statistically significant associations but did not derive ORs; two studies found ORs greater than 3.0, seven studies from 1 to 3.0, and 2 studies with ORs less than 1.0.

There is **strong evidence** that working groups with high levels of static contraction, prolonged static loads, or extreme working postures involving the neck/shoulder muscles are at increased risk for neck/shoulder MSDs. Consistently high ORs (12 studies found statistically significant ORs over 3.0) for tension neck syndrome associated with static postures or static loads have been found.

The epidemiologic data are **insufficient** to document relationship of vibration and neck disorders. The few prospective studies which have included interventions to decrease workplace risk factor exposures, including decreasing repetitive work and less extreme working postures, have shown a decrease in incidence of neck MSDs, and an improvement in symptoms among affected workers. These data provide additional evidence that these disorders are related to work factors.

However, cumulative exposure-response data is lacking, although VDT studies using surrogate exposure variables suggests a relationship.

Table 2-1. Epidemiologic criteria used to examine studies of neck MSDs associated with repetition

Study (first author and year)	Risk indicator (OR, PRR, IR or *p*-value)*,†	Participatio n rate $70%	Physical examinatio n	Investigator blinded to case and/or exposure status	Basis for assessing neck exposure to repetition
Met all four criteria:					
Ohlsson 1995	3.6[†]	Yes	Yes	Yes	Observation or measurements
Met at least one criterion:					
Andersen 1993b	6.8[†]	Yes	Yes	Yes	Job titles or self-reports
Baron 1991	2.0	No	Yes	Yes	Job titles or self-reports
Bergqvist 1995b	6.9[†]	Yes	Yes	Yes	Job titles or self-reports
Hales 1989	1.6	Yes	Yes	Yes	Job titles or self-reports
Kamwendo 1991	1.65[†]	Yes	No	NR[‡]	Job titles or self-reports
Kiken 1990	1.3	Yes	Yes	Yes	Job titles or self-reports
Knave 1985	NR[†]	Yes	No	NR	Job titles or self-reports
Kuorinka 1979	4.1[†]	Yes	Yes	NR	Job titles or self-reports
Luopajärvi 1979	1.6	Yes	Yes	Yes	Job titles or self-reports
Onishi 1976	3.8[†]	NR	Yes	NR	Observation or measurements
Sakakibara 1987	NR[†]	Yes	No	NR	Job titles or self-reports
Schibye 1995	3.3[†]	Yes	No	NR	Job titles or self-reports
Yu 1996	28.9[†]	Yes	No	NR	Job titles or self-reports
Met none of the criteria:					
Liss 1995	1.7[†]	No	No	No	Job titles or self-reports
Ohlsson 1989	1.9	NR	No	NR	Job titles or self-reports

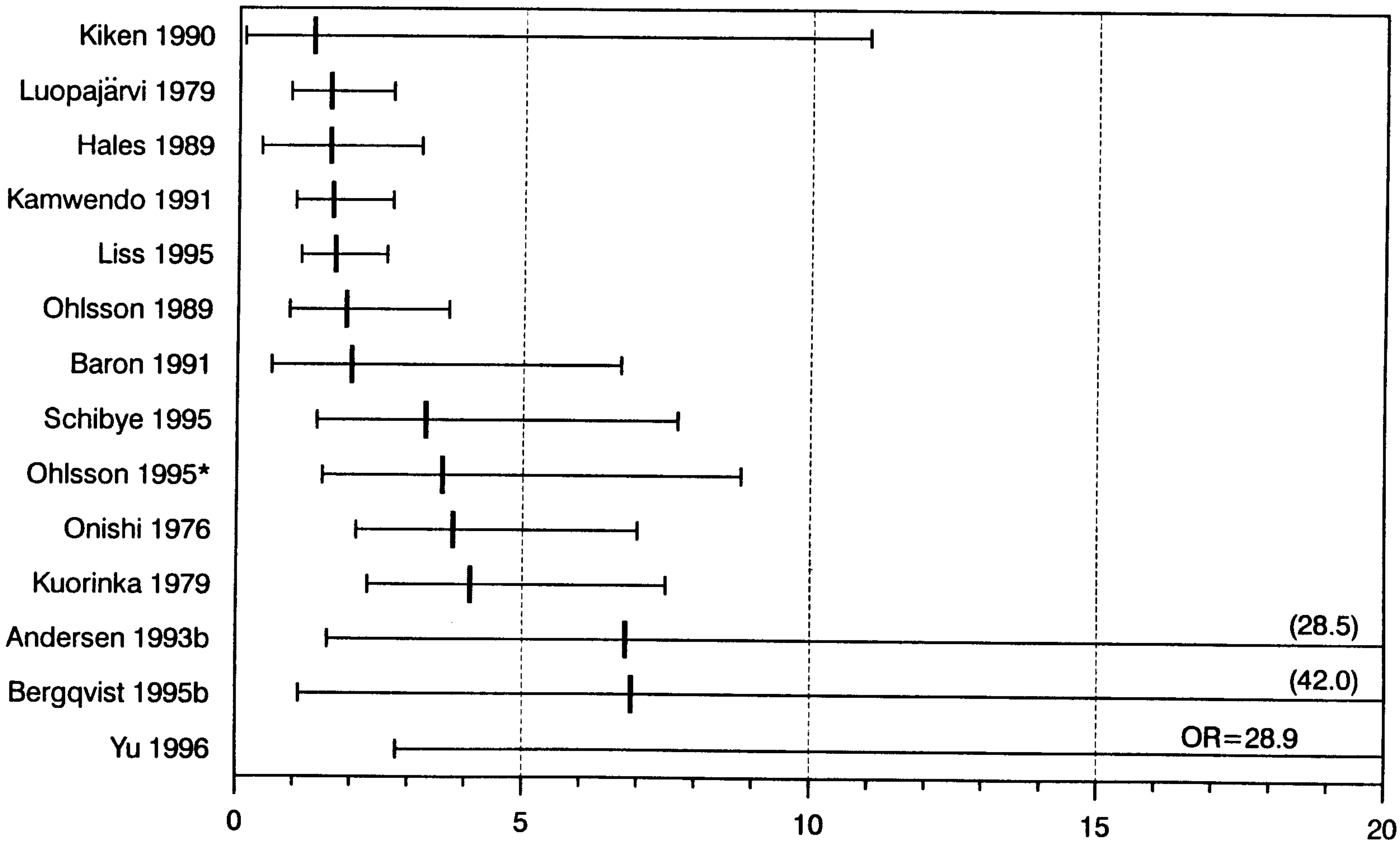
[*]Some risk indicators are based on a combination of risk factors—not on repetition alone (i.e., repetition plus force, posture, or vibration). Odds ratio (OR), prevalence rate ratio (PRR), or incidence ratio (IR).

[†]Indicates statistical significance. If combined with NR, a significant association was reported without a numerical value.

[‡]Not reported.

Figure 2-1. **Risk Indicator for "Repetition" and Neck Musculoskeletal Disorders**

(Odds Ratios and Confidence Intervals)



* Studies which met all four criteria.

Note: Two studies indicated statistically significant associations without reporting odds ratios. See Table 2-1.

Table 2-2. Epidemiologic criteria used to examine studies of neck/shoulder MSDs associated with repetition

Study (first author and year)	Risk indicator (OR, PRR, IR or *p*-value)*,†	Participation rate $70%	Physical examinatio n	Investigator blinded to case and/or exposure status	Basis for assessing neck/shoulder exposure to repetition
Met all four criteria:					
Jonsson 1988	NR[†,‡]	Yes	Yes	Yes	Observation or measurements
Ohlsson 1995	4.6[†]	Yes	Yes	Yes	Observation or measurements
Met at least one criterion:					
Andersen 1993a	4.6[†]	Yes	No	Yes	Job titles or self-reports
Bergqvist 1995a	3.6	Yes	No	Yes	Observation or measurements
Blåder 1991	NR[†]	Yes	Yes	No	Job titles or self-reports
Ekberg 1994	15.6[†]	Yes	No	NR	Job titles or self-reports
Ekberg 1995	1.2[†]	Yes	No	NR	Job titles or self-reports
Hünting 1981	9.9[†]	NR	Yes	NR	Observation or measurements
Milerad 1990	2.1[†]	Yes	No	NR	Job titles or self-reports
Punnett 1991	1.8	Yes	No	NR	Observation or measurements
Rossignol 1987	1.8–4.6[†]	Yes	No	NR	Job titles or self-reports
Vihma 1982	1.6[†]	NR	No	NR	Observation or measurements

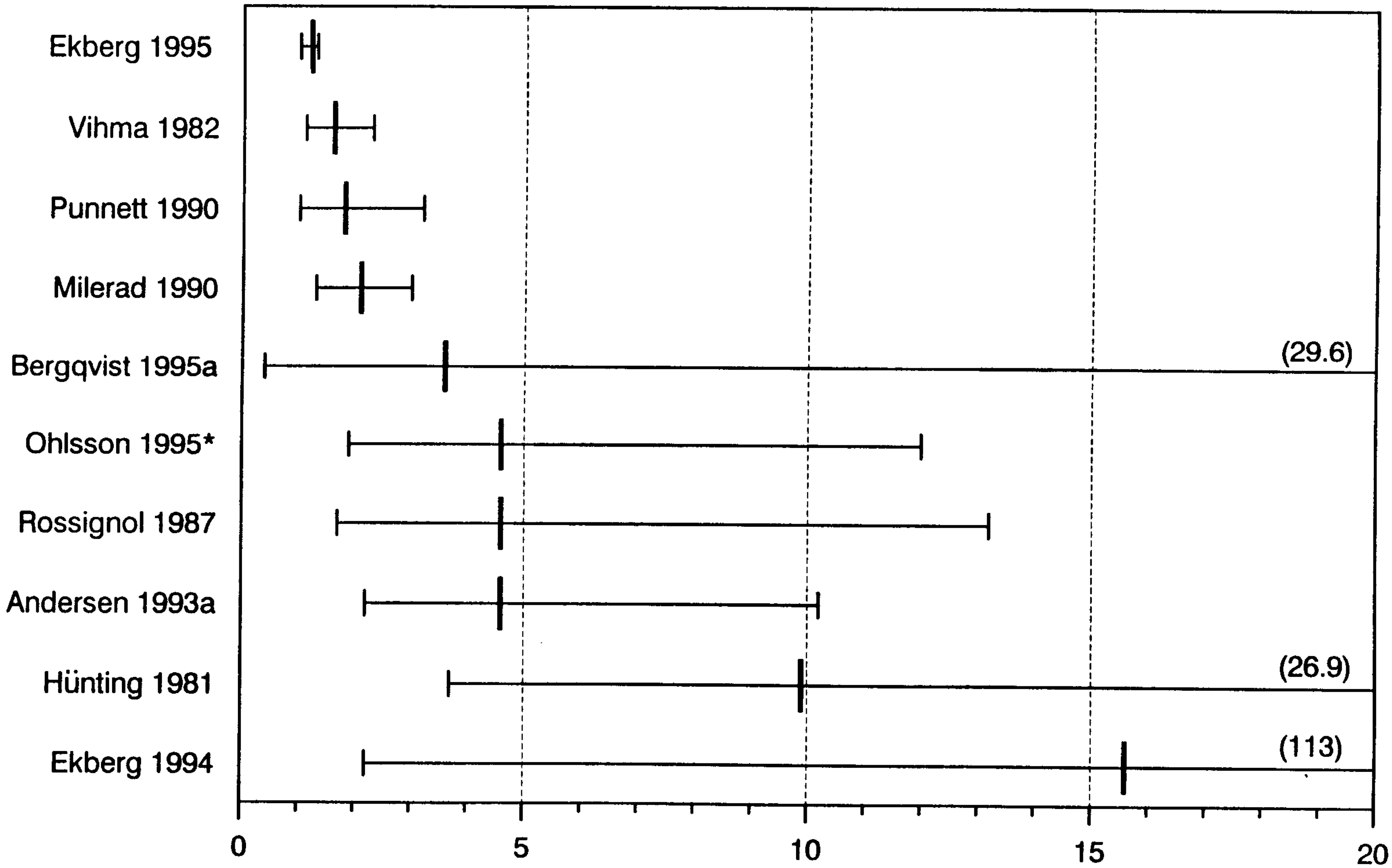
[*]Some risk indicators are based on a combination of risk factors—not on repetition alone (i.e., repetition plus force, posture, or vibration). Odds ratio (OR), prevalence rate ratio (PRR), or incidence ratio (IR).

[†]Indicates statistical significance. If combined with NR, a significant association was reported without a numerical value.

[‡]Not reported.

Figure 2-2. **Risk Indicator for "Repetition" and Neck/Shoulder Musculoskeletal Disorders**

(Odds Ratios and Confidence Intervals)



* Studies which met all four criteria.

Note: Two studies indicated statistically significant associations without reporting odds ratios. See Table 2-2.

Table 2-3. Epidemiologic criteria used to examine studies of neck MSDs associated with force

Study (first author and year)	Risk indicator (OR, PRR, IR or *p*-value)*,†	Participation rate ≥70%	Physical examination	Investigator blinded to case and/or exposure status	Basis for assessing neck exposure to force
Met at least one criterion:					
Baron 1991	2.0	No	Yes	Yes	Job titles or self-reports
Hales 1989	1.6	Yes	Yes	Yes	Job titles or self-reports
Kiken 1990	1.3	Yes	Yes	Yes	Job titles or self-reports
Kuorinka 1979	4.1[†]	Yes	Yes	NR[‡]	Job titles or self-reports
Luopajärvi 1979	1.6	Yes	Yes	Yes	Job titles or self-reports
Veiersted 1994	6.7[†]	No	Yes	NR	Observation or measurements
Viikari-Juntura 1994	3.0[†]	Yes	No	Yes	Job titles or self-reports
Wells 1983	2.57[†]	Yes	No	NR	Job titles or self-reports
Met none of the criteria:					
Liss 1995	1.7[†]	No	No	No	Job titles or self-reports

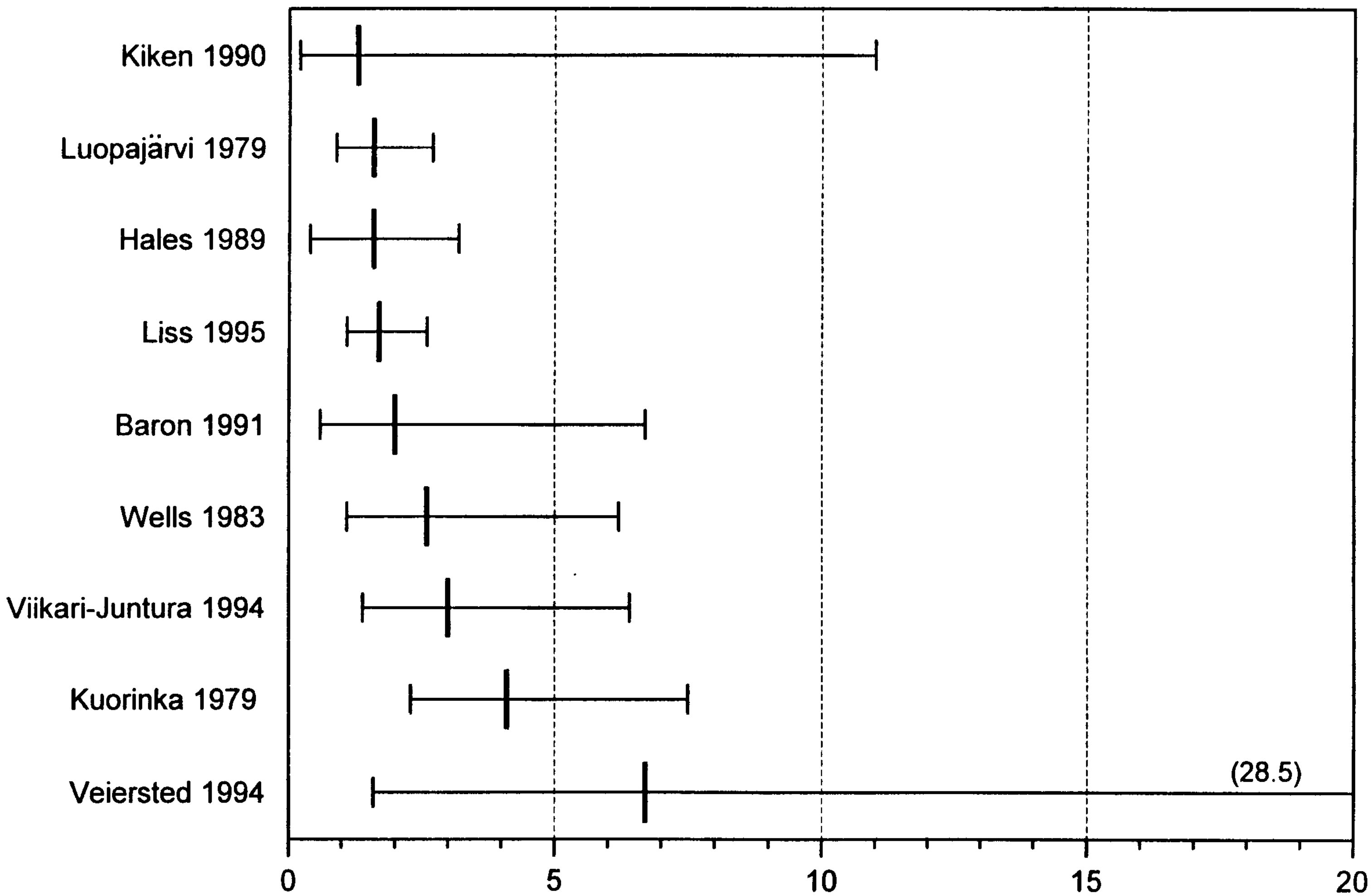
[*]Some risk indicators are based on a combination of risk factors—not on force alone (i.e., force plus repetition, posture, or vibration). Odds ratio (OR), prevalence rate ratio (PRR), or incidence ratio (IR).

[†]Indicates statistical significance.

[‡]Not reported.

Figure 2-3. **Risk Indicator for "Force" and Neck Musculoskeletal Disorders**

(Odds Ratios and Confidence Intervals)



Note: One study indicated a statistically significant association without reporting odds ratios. See Table 2-3.

Table 2-4. Epidemiologic criteria used to examine studies of neck/shoulder MSDs associated with force

Study (first author and year)	Risk indicator (OR, PRR, IR or *p*-value)*,†	Participation rate $70%	Physical examination	Investigator blinded to case and/or exposure status	Basis for assessing neck/shoulder exposure to force
Met at least one criterion:					
Åaras 1994	NR[†,‡]	NR	No	NR	Observation or measurements
Andersen 1993a	3.2	Yes	No	Yes	Job titles or self-reports
Bjelle 1981	NR[†]	NR	Yes	Yes	Observation or measurements
Jonsson 1988	NR[†]	Yes	Yes	Yes	Job titles or self-reports
Punnett 1991	0.9 (females) 1.8 (males)	Yes	No	NR	Observation or measurements

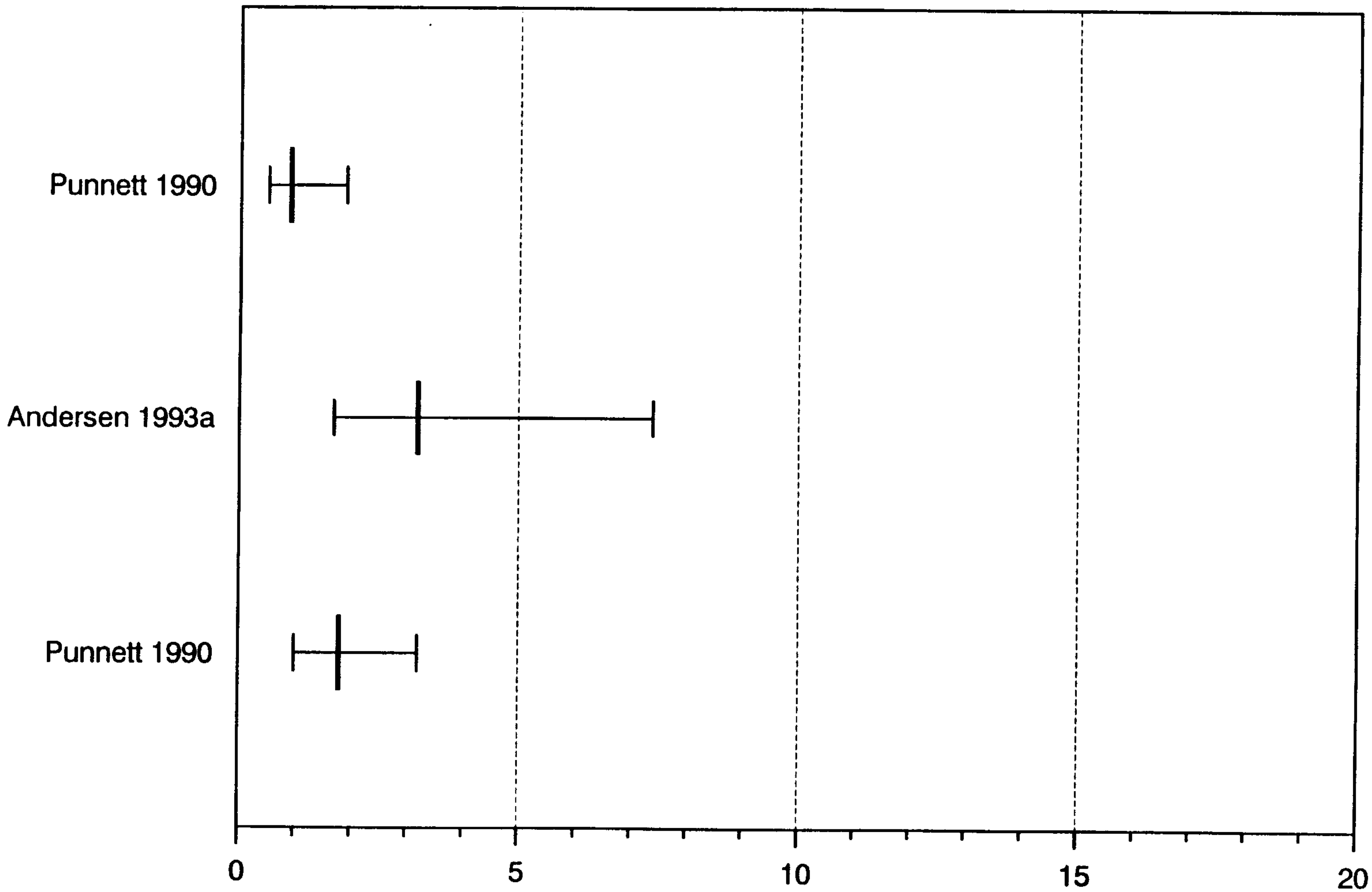
[*]Some risk indicators are based on a combination of risk factors—not on force alone (i.e., force plus repetition, posture, or vibration). Odds ratio (OR), prevalence rate ratio (PRR), or incidence ratio (IR).

[†]Indicates statistical significance. If combined with NR, a significant association was reported without a numerical value.

[‡]Not reported.

Figure 2-4. **Risk Indicator for "Force" and Neck/Shoulder Musculoskeletal Disorders**

(Odds Ratios and Confidence Intervals)



Note: Three studies indicated statistically significant associations without reporting odds ratios. See Table 2-4.

Table 2-5. Epidemiologic criteria used to examine studies of neck MSDs associated with posture

Study (first author and year)	Risk indicator (OR, PRR, IR or *p*-value)*,†	Participation rate $70%	Physical examination	Investigator blinded to case and/or exposure status	Basis for assessing neck exposure to posture
Met at least one criterion:					
Bernard 1994	1.4[†]	Yes	No	Yes	Job titles or self-reports
Ferguson 1976	NR[‡]	Yes	No	No	Observation or measurements
Hales 1994	3.8[†]	Yes	Yes	Yes	Job titles or self-reports
Kamwendo 1991	1.65[†]	Yes	No	NR	Job titles or self-reports
Kukkonen 1983	3.6[†]	NR	Yes	Yes	Job titles or self-reports
Kuorinka 1979	4.1[†]	Yes	Yes	NR	Job titles or self-reports
Linton 1990	3.5[†]	Yes	No	NR	Job titles or self-reports
Onishi 1976	3.8[†]	NR	Yes	NR	Observation or measurements
Sakakibara 1987	NR[†]	Yes	No	NR	Observation or measurements
Sakakibara 1995	1.5	Yes	Yes	NR	Observation or measurements
Veiersted 1994	7.2[†]	No	Yes	NR	Observation or measurements
Viikari-Juntura 1994	3.9–4.2[†]	Yes	No[§]	Yes	Job titles or self-reports
Welch 1995	7.5	Yes	No	No	Job titles or self-reports
Wells 1983	2.57[†]	Yes	No	NR	Job titles or self-reports
Yu 1996	784.4[†]	Yes	No	NR	Job titles or self-reports

*Some risk indicators are based on a combination of risk factors—not on posture alone (i.e., posture plus force, repetition, or vibration). Odds ratio (OR), prevalence rate ratio (PRR), or incidence ratio (IR).

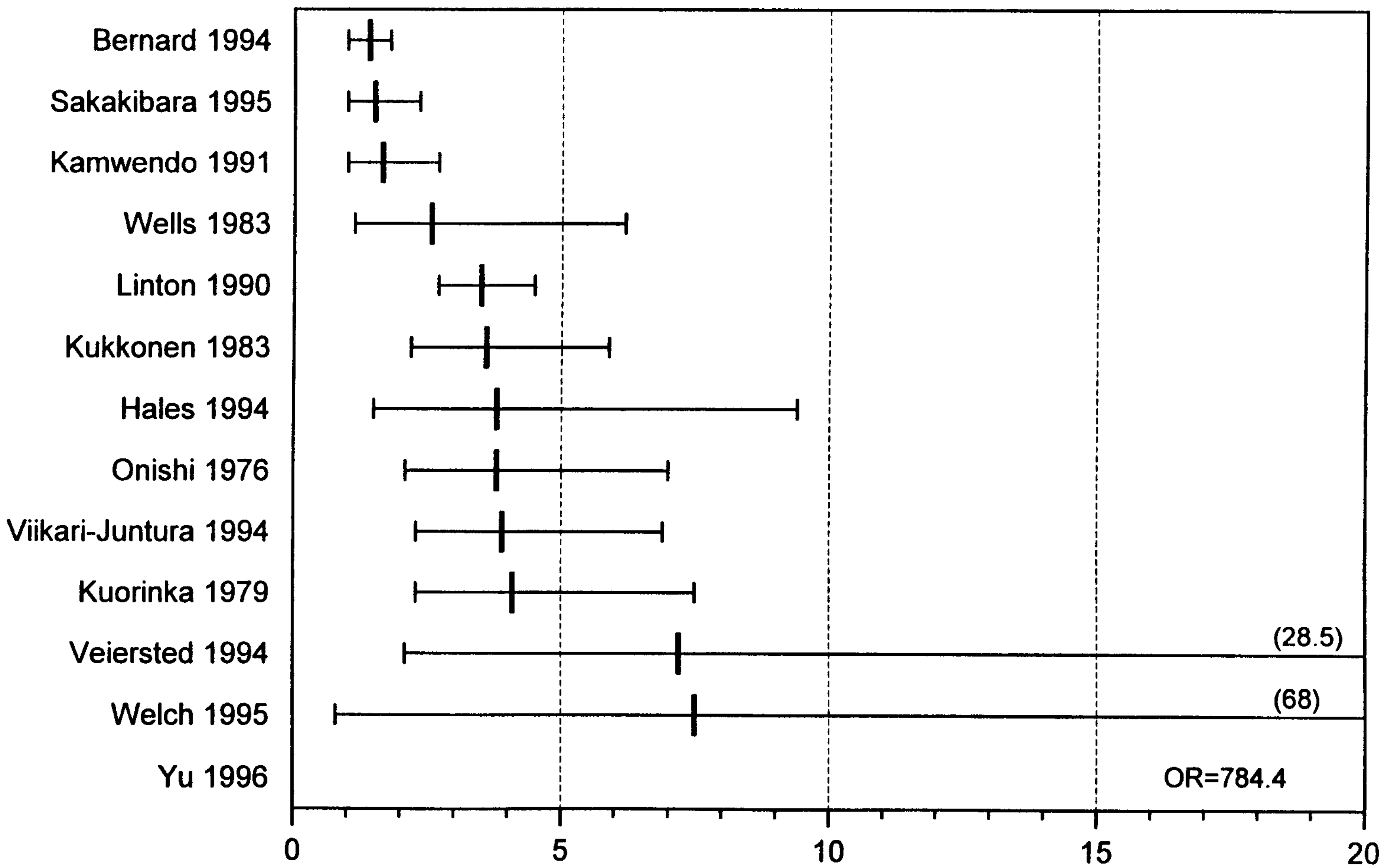
†Indicates statistical significance. If combined with NR, a significant association was reported without a numerical value.

‡Not reported.

§Physical examinations were not analyzed because there were too few cases.

Figure 2-5. **Risk Indicator for "Posture" and Neck Musculoskeletal Disorders**

(Odds Ratios and Confidence Intervals)



Note: Two studies indicated statistically significant associations without reporting odds ratios. See Table 2-5.

Table 2-6. Epidemiologic criteria used to examine studies of neck/shoulder MSDs associated with posture

Study (first author and year)	Risk indicator (OR, PRR, IR or *p*-value)*,†	Participation rate $70%	Physical examination	Investigator blinded to case and/or exposure status	Basis for assessing neck/shoulder exposure to posture
Met all four criteria:					
Jonsson 1988	NR[†,‡]	Yes	Yes	Yes	Observation or measurements
Kilbom 1986	NR[†]	Yes	Yes	Yes	Observation or measurements
Ohlsson 1995	NR[†]	Yes	Yes	Yes	Observation or measurements
Met at least one criterion:					
Åaras 1994	NR[†]	NR	No	NR	Observation or measurements
Bergqvist 1995a	4.4[†]	Yes	No	Yes	Observation or measurements
Bjelle 1981	NR[†]	NR	Yes	Yes	Observation or measurements
Blåder 1991	NR[†]	Yes	Yes	No	Job titles or self-reports
Ekberg 1994	4.8[†], 3.6[†]	Yes	No	NR	Job titles or self-reports
Holmström 1992	2.0[†]	Yes	No	Yes	Job titles or self-reports
Hünting 1981	9.9[†]	NR	Yes	NR	Observation or measurements
Milerad 1990	2.6[†]	Yes	No	NR	Job titles or self-reports
Rossignol 1987	1.8, 4.0[†], 4.6[†]	Yes	No	NR	Job titles or self-reports
Ryan 1988	NR[†]	Yes	No	Yes	Observation or measurements
Tola 1988	1.8[†]	Yes	No	NR	Job titles or self-reports
Vihma 1982	1.6[†]	NR	No	NR	Observation or measurements
Viikari-Juntura 1991a	1.5	Yes	Yes[§]	NR	Job titles or self-reports

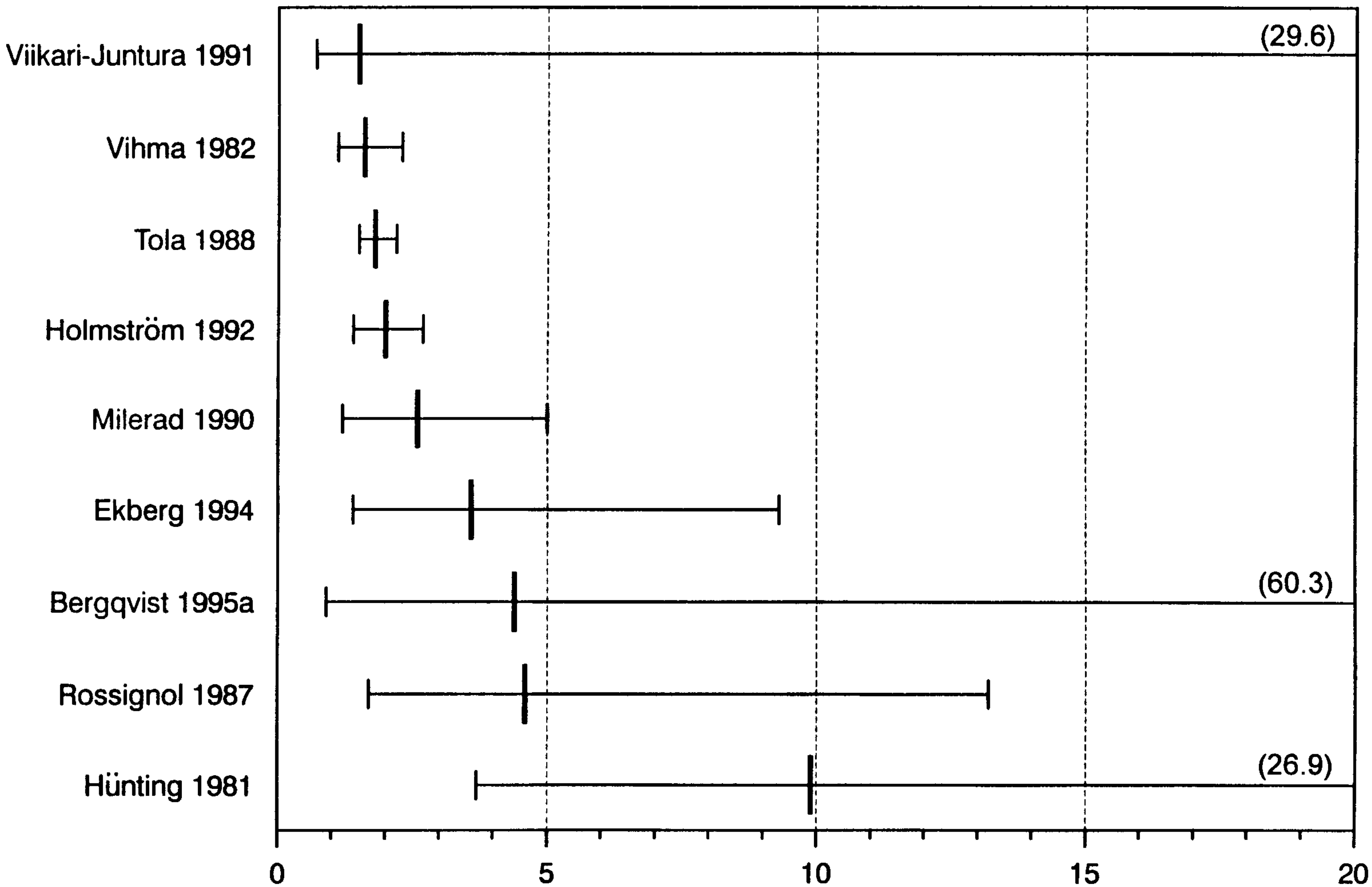
*Some risk indicators are based on a combination of risk factors—not on posture alone (i.e., posture plus force, repetition, or vibration). Odds ratio (OR), prevalence rate ratio (PRR), or incidence ratio (IR).

†Indicates statistical significance. If combined with NR, a significant association was reported without a numerical value.

‡Not reported.

Figure 2-6. **Risk Indicator for "Posture" and Neck/Shoulder Musculoskeletal Disorders**

(Odds Ratios and Confidence Intervals)



Note: Seven studies indicated statistically significant associations without reporting odds ratios. See Table 2-6.

Table 2–7. Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD Prevalence: Exposed workers	MSD Prevalence: Referent group	MSD Prevalence: RR, OR, or PRR	MSD Prevalence: 95% CI	Comments
Andersen and Gaardboe 1993a	Cross-sectional	701 female sewing machine operators (SMO), compared to 781 females from the general population of the region and internal referent group of 89 females from the garment industry.	Outcome: Case of chronic pain was defined as continuous pain lasting for a month or more after beginning work and pain for $30 days within the past year. Exposure: Job categorization based on "authors' experiences as occupational health physicians" and involved crude assessment of exposure level and exposure repetitveness. Jobs involving high repetitiveness (several times/min) and low or high force, and jobs with medium repetitiveness (many times/hr) combined with high force were classified as high exposed jobs; jobs with medium repetitiveness and low force and jobs with more variation and high force were classified as medium exposed. Job titles such as teachers, self-employed, trained nurses, and the academic professions were "low exposed."	26.2%	General population: 9.9% Internal referent group: 6.7%	SMO compared to: (1) General population: OR=3.2 (2) Internal referent group: OR=4.9 Logistic Model: Years as SMO: 0 to 7 years: 1.9 8 to 15 years: 3.8 >15 years: 5.0 Age $ 40 years: 1.5 Children (>0): 1.3 Exercise: 0.9 Socioeconomic status: 1.29 Smoking: 1.39 Current Exposure: 1.3	2.3-4.5 2.0-12.8 1.3-2.9 2.3-6.4 2.9-8.7 1.1-2.2 0.8-2.0 0.6-1.3 0.7-2.3 0.99-1.9 0.9-1.9	Participation rate: 78.2%. Examiners blinded to control/subject status. Controlled for age, having children, not doing leisure exercise, smoking socioeconomic status. Age-matched exposure groups and controls. Logistic regression limited to a combined neck/shoulder case definition. No difference in education, marital status, number of children. Poor correlation between degenerative X-ray neck changes and cervical syndrome. Most frequent diagnosis among study group was "cervicobrachial fibromyalgia" significant for test of trend with exposure time in years. Chronic neck pain and palpatory findings: Sensitivity: 0.85; Specificity: 0.93.

(Continued)

Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Andersen and Gaardboe 1993b	Cross-sectional	From a historical cohort of 424 sewing machine operators, 120 were randomly selected and 82 exposed workers were categorized by number of years of employment: 0-7 years, 8-15 years and greater than 15 years. These were compared to a referent group of 25 auxiliary nurses and home helpers. A total of 107 subjects participated.	Outcome: Measured by health interview and exam of the neck, shoulder and arm. Case of chronic pain was defined as continuous pain lasting for a month or more after beginning work and pain for at least 30 days within the past year. Physical examination: Restricted movements in the cervical spine and either palpatory tenderness in cervical segments or irradiating pain or tingling at maximum movements or positive foraminal test. Exposure: Exposure categorization broken down according to current occupational status by job title. Classification into exposure groups based on author's experiences as occupational health physicians and involved crude assessment of exposure level and exposure repetitiveness. High exposure jobs: Involved high repetition/high force or high repetition/low force or medium repetition/high force. Medium exposure jobs involved medium repetition/low force and low repetition and high force. Low exposure jobs were low repetition/low force.		Referents: OR=1	0 to 7 years: 2.3 8 to 15 years: 6.8 >15 years: 16.7 Age at least 40 years: 1.9 Children >0 years: 0.5 Exercise: 1.4 Smoking: 1.5 Current high exposure: 1.6	0.5-11 1.6-28.5 4.1-67.5 O.9-4.1 0.1-1.7 0.6-2.96 0.7-3.3 0.7-3.6	Participation rate: 78.2%; logistic regression limited to a combined neck/shoulder case definition. Age-matched exposure groups and controls. Examiners blinded to control/subject status. Controlled for age, having children, not doing leisure exercise, smoking, socioeconomic status. Poor correlation between degenerative X-ray neck changes and cervical syndrome. Most frequent diagnosis among study group was "cervicobrachial fibromyalgia" significant for test of trend with exposure time in years. Chronic neck pain vs. palpatory findings: Sensitivity: 0.85; Specificity: 0.93.

(Continued)

Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Baron et al. 1991	Cross-sectional	124 grocery checkers using laser scanners (119 females, 5 males) compared to 157 grocery non-checkers (56 females, 101 males); excluded 18 workers in meat, fish, and deli departments, workers under 18 and pregnant workers.	Outcome: Based on symptom questionnaire and physical exam. Case defined as having positive symptoms and a positive physical exam. Symptoms must have begun after employment at supermarket of employment and in current job; lasted one week or occurred once a month during the past year; no history of acute injury to part of body in question. Exposure: Based on job categorization. Estimates of repetition and average and peak forces of hand and wrist based on observed and videotaped postures, weight of scanned items, and subjective assessment of exertion. Specific neck assessment was not done.	16%	5%	Odds of neck pain, checkers vs. non-checkers: OR=2	0.6-6.7	Participation rate: 85% checkers; 55% non-checkers in field study. Following telephone survey 91% checkers and 85% non-checkers. Examiners blinded to worker's job and health status. Adjusted for duration of work, age, hobbies, systemic disease obesity. Total repetitions/hr ranged from 1,432 to 1,782 for right hand and 882 to 1,260 for left hand. Average forces for cashiers were low and peak forces medium. Force was not analyzed in the models. Multiple awkward postures of all upper extremities recorded but not analyzed in models. Statistically significant increase in neck MSD with increase in years "checking."

(Continued)

Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Bergqvist et al. 1995a	Cross-sectional	Office workers using VDTs, (n=260), 198 females; symptomatic cases compared to non-cases.	Outcome: Neck discomfort— any discomfort over the last 12 months; intense neck discomfort— as above, if occurred in last 7 days and interfered with work. Outcome: Physiotherapist's diagnosis of: (1) tension neck syndrome (TNS): ache/pain in the neck; feeling of tiredness and stiffness in neck; possible headache; pain during movements; muscular tenderness; (2) cervical diagnoses—ache/pain in neck and arm; headache; decreased mobility due to cervical pain during isometric contraction; often root symptoms such as numbness or parathesias. Exposure: Based on observation— static work posture, nonuse of lower arm support, hand in non-neutral position, insufficient leg space at table, repeated movements with risk of tiredness, specular glare present on VDT. Measured: Height difference of VDT keyboard-elbow, high visual angle to VDT.	Neck: 61.5% Female: 63% Male: 57% TNS: 22% Female: 25% Male: 13% Cervical diagnosis: 23% Female: 25% Male: 20%	Asymptomatic workers	Tension neck syndrome: Females no children: OR= 2.0 Females with children: OR=6.4 Limited rest break: OR=7.4 Too highly place keyboard: OR=4.4 Cervical Diagnoses: Age >40 OR=2.7 Spectacles: OR=4.0 Static Posture: OR=5.1 Spectral glare: OR=1.9 Stomach reactions: OR=3.9 Tiredness: 1.9	0.7-5.6 1.9-21.5 3.1-17.4 1.1-17.6 1.0-7.2 1.3-12.5 0.6-42.5 0.9-4.2 2.0-7.7 1.0-3.5	Participation rate: 92% of 353 office workers. Adjusted for age and gender. Factors included in analysis: Age, gender, smoking, children at home, negative affectivity, tiredness-related stress reaction, stomach-related stress reaction, use of spectacles, peer contacts, rest breaks, work task flexibility, overtime, static work position, non-use of lower arm support, hand in non-neutral posture, repeated movements with risk of tiredness, height differences keyboard/elbow, high visual angle to VDT, glare on VDT. Found that “frequent overtime” protective for cervical diagnoses OR=0.48 (0.23, 0.99). Examiner and workplace investigators blinded to case and exposure status. There are problems with interpreting results because of multiple comparisons and multiple models. Not all significant findings presented in paper.

(Continued)

Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

				MSD prevalence				
Study	Study design	Study population	Outcome and exposure	Exposed workers	Referent group	RR, OR, or PRR	95% CI	Comments
Bergqvist et al. 1995b	Cross-sectional	322 office workers; VDT users compared to non-VDT users. 52% interactive, 29% data entry, 19% non-VDT users.	Outcome: Neck discomfort—any discomfort over the last 12 months; intense neck/shoulder discomfort—as above, if occurred in last 7 days and interfered with work. Outcome: Physiotherapist's diagnosis of tension neck syndrome (TNS)—ache/pain in the neck; feeling of tiredness and stiffness in neck; possible headache; pain during movements; muscular tenderness. Exposure: Based on self-reporting of VDT use. VDT users categorized into data entry or interactive VDT users.	Neck discomfort: 60% Intense neck discomfort: 7.4% Tension neck syndrome: 21%		Current VDT work: OR=1.4 Intense neck discomfort: OR=0.5 Tension neck syndrome: OR=1.0 TNS Diagnosis: <20 hr/week VDT: 1.2 >20 hr/week VDT: 0.7 TNS diagnosis with bifocal or progressive glasses at VDT work and $20 hr/week VDT work duration: OR=6.9	0.8-2.4 0.2-1.8 0.5-1.9 0.4-3.7 0.3-1.5 1.1-42.1	Participation rate: 76%. Adjusted for age and gender. Intensive neck discomfort associated with VDT work over 20 hr and having stomach reactions often and repetitive movements: OR=3.9 (1.1, 13.8). Originally 535 workers queried in 1981. Of those, 182 had left the workplace (quit, retired, etc.). Possible bias from "healthy worker effect." Covariates considered: Children at home, smoking, negative affectivity, stomach-related stress reactions, tiredness-related stress reactions. Organizational factors considered: limited or excessive peer contacts, limited rest break opportunity, limited work task flexibility, frequent overtime. For cervical diagnoses: Excess OR suggested for combined occurrence of VDT work of >20 hr/week and specular glare on the VDT screen.

(Continued)

Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

				MSD prevalence				
Study	Study design	Study population	Outcome and exposure	Exposed workers	Referent group	RR, OR, or PRR	95% CI	Comments
Bernard et al. 1994	Cross-sectional	Of a total population of 3,000 workers in the editorial, circulation classified advertising and accounting departments, 1,050 were randomly selected for study and 973 participated. Those fulfilling case definition compared to those workers not fulfilling definition.	Outcome: Health data and psychosocial information were collected using a self-administered questionnaire. Definition: Presence of pain, numbness, tingling, aching, stiffness or burning in the neck occurring $ once a month or 7 days continuously within the past year, reported as moderately severe. The symptom must have begun during the current job. Workers with previous nonoccupational injuries to the relevant area were excluded. Exposure: Based on observation of work activity involving keyboard work, work pace, posture, during a typical day of a sample of 40 workers with and 40 workers without symptoms. Exposure to work organization and psychosocial factors based on questionnaire responses.	26% (case) Cases with daily neck pain: 22%	Õ Õ	Females: OR=2.1 Number of hr spent on deadline/week (30 to 39 hr vs. 0 to 10 hr) OR=1.7 Work variance (continually changing work load; occasionally vs. often) OR=1.7 Time spent on the telephone (4 to 6 hr vs. 0 to 2 hr): OR=1.4 Perceived lack of importance for ergonomic issues by management: OR=1.9	1.4-2.4 1.4-3.0 1.2-2.5 1.0-1.8 1.4-2.4	Participation rate: 93%. Examiners blinded to case and exposure status. Analysis controlled for confounders, age, gender, height, psychosocial factors, medical conditions. Psychosocial scales analyzed by splitting the responses into quartiles, then comparing the 75% response score to the 25% response score for deriving the ORs in each scale. In sub-analysis of jobs having comparable number of males and females. Only number of hr spent on deadline/week and perceived lack of importance for ergonomic issues by management were significant.

(Continued)

Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Ferguson 1976	Cross-sectional	418 telephonists interviewed	Outcome: Symptoms by questionnaire. Neck ache categorized on 3-point discomfort scale: (1) very comfortable, (2) barely comfortable, and (3) uncomfortable, very uncomfortable. Exposure: Personal and social attributes and attitudes to aspects of the work and the equipment were obtained by questionnaire. Seven body dimensions were measured, and standing posture was categorized by observation against a grid according to predetermined criteria.	Telephonists: Uncomfortable or very uncomfortable neck ache =26%		Chi sq=11.01 (df=2), $p<0.005$		Participation rate: 95%. Although author states the following: "Discomfort, aching, and other symptoms are common, important but usually neglected problems in telephonists which could be ameliorated by ergonomic job and equipment," the results of his study did not support his conclusion. Neither discomfort nor aching was linked to any of the body postures observed. Height and weight were not related to discomfort or aching. Multiple correlations not helpful in identifying combinations of personal, equipment, environmental or other variables predictive of aching and discomfort.

(Continued)

Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Hales and Fine 1989	Cross-sectional	Of 96 female workers employed in 7 high exposure jobs in poultry processing: 89 were compared to 23 of 25 female workers in low exposure jobs.	Outcome: Period prevalence—symptoms in last 12 months by questionnaire. Case defined as: Pain, aching, stiffness, numbness, tingling or burning in the neck and symptoms began after employment at the plant; were not due to a previous injury or trauma to the joint; lasted >8 hr; and occurred 4 or more times in the past year. Point prevalence: Determined by physical exam of the neck using standard diagnostic. Tension neck syndrome: Palpable muscle tightness, hardening or pain $ 3 (on 8 point scale) on passive or resisted neck flexion or rotation. Cervical root syndrome: Pain $ (on 8 point scale) radiating from neck to one or both arms with numbness in the hand criteria. Case must also fulfill symptom definition. Exposure: Observation and walk-throughs; jobs categorized as high exposure and low exposure based on estimates of force and repetition of hand maneuvers.	Period prevalence: 21% Point prevalence: 12%	Period prevalence: 13% Point prevalence: 0%	Outcome: Neck symptoms: RR=1.64 Outcome: Neck symptoms and physical: OR indeterminate because of "0" cell Estimated OR by adding 1 to each cell in crude 2 X 2 table: 3.69	0.4-3.19 0.4-164	Participation rate: 93%. Adjustment for age and duration of employment. Examiner blinded to case and exposure status. Exposure based on repetitive and forceful hand/wrist motions and not neck exposure assessment. 80% of workers involved in job rotation program. No information collected on non-work related risk factors.

(Continued)

Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Hales et al. 1994	Cross-sectional	Telecommunication workers (n=518, 416 females, 117 males) in 3 offices, employed > 6 months. "Cases" fulfilling neck work-related MSD definition compared to non-cases.	Outcome: Self-administered questionnaire and standardized physical exam (PE). Case defined as: Pain, aching, stiffness, burning, numbness or tingling lasting >1 week or >12 times a year; no previous traumatic injury to neck; occurring after employment on current job within the last year and positive PE—moderate to worst pain experienced with tension neck or cervical root syndrome. Exposure: Assessed by questionnaire and observation; number of keystrokes/day; no exposure questions were specifically aimed at the neck region. Physical workstation and postural measurements were taken but not analyzed in models.	9%	õ õ	Lack of decision making opportunities: OR=4.2 Use of bifocals: OR=3.8 Lack of a productivity standard: OR=3.5 Fear of being replaced by computers: OR=3.0 High information processing demands: OR=3.0 Job requiring a variety of tasks: OR=2.9 Increasing work procedure: OR=2.4	2.1-8.6 1.5-9.4 1.5-8.3 1.5-6.1 1.4-6.2 1.5-5.8 1.1-5.5	Participation rate: 93%. Physician examiner blinded to worker case status. Logistic analysis adjusted for demographics, work practices, work organization, individual factors; electronic performance monitoring; DAO keystrokes; Denver DAO keystrokes/day. ORs for psychosocial variables represent risk at scores one standard deviation above mean score compared to risk at scores one SD below mean. Because of readjustments and changes of workstations during study period, measurements of VDT workstations considered unreliable and excluded from analyses. Number of hr spent in hobbies and recreational activities not significant. Although keystrokes/day found not significant, data available was for workers typing an average of 8 words/min over 8-hr period. 97% of participants used VDT $6 hr so not enough variance to evaluate hr of typing. Over 70 variables analyzed in models may have multiple comparison problem.

(Continued)

Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	Referent group	RR, OR, or PRR	95% CI	Comments
Hunting et al. 1994	Cross-sectional	308 of 400 apprentice and journeymen, electricians from one labor union participated.	Outcome: Three-symptom definitions used; most restrictive includes neck symptoms occurring $once/month or lasting >1 week during past year, and no previous traumatic injury to site. Exposure: Questionnaire dealing with lifting activities, working overhead, working with hand tools.	16% 3% with medical visits, missed work, or light duty	õ õ	õ õ 1 to 3 years worked: OR=1 4 to 5 years worked: OR=1.3 6 to 10 years worked: OR=1.6 >10 years worked: OR=1.3	õ õ	Participation rate: 75%. 98% of participants were male. Stratified by most experienced vs. least experienced electrician, by years worked, by age group, current work as an electrician. Analysis of specific work factors (repetition, force, extreme posture, vibration, or combinations of risk factors) not analyzed in this paper which dealt with prevalence of symptoms among electricians.

(Continued)

Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Kamwendo et al. 1991	Cross-sectional	420 medical secretaries; compared those frequently having neck pain to those less frequently having pain.	Outcome: Questionnaire using 6 point scale ranging from "very often" to "almost never" and Nordic Questionnaire. Definition of neck MSD: Discomfort, ache, or pain during previous year; whether they had pain in last 7 days, whether pain prevented them from doing daily duties. 10 questions on psychosocial work environment included. Exposure: Based on questionnaire. Low exposure was regarded as 1 to 4 hr sitting or working with office machines, high exposure was regarded as 5 to 8 hr.	63% period prevalence. 33% point prevalence. 15% with constant neck pain.	õ õ	OR for work with office machines 5 hr or more/day: 1.65 Working >5 years: OR=1.6 Sitting 5 or more hr/day: OR=1.9	1.02-2.67 0.9-2.8 0.86-2.6	Participation rate: 96%. Neck symptoms associated with a "poorly experienced psychosocial work environment." Age, length of employment significantly related to neck pain. Questionnaire included psychosocial scales, length of employment, part-time or full-time work, average hr sitting working with machines. Ability to influence work, a friendly spirit of cooperation between co-workers, being given too much to do significantly positively associated with neck pain.

(Continued)

Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Kiken et al. 1990	Cross-sectional	294 poultry processors. Plant #1 (n=174) Plant #2 (n=120)	Outcome: Period prevalence—based on questionnaire. Case—pain, aching, stiffness, burning, numbness or tingling in the neck, began after employment at the plant; not due to previous accident or injury outside work; lasted >8 hr and occurred 4 or more times in the past year.	Plant #1: (High exposure) Any symptoms: 34%	Plant #1: (Low exposure) Any symptoms: 16%	OR= 2.2	0.9-5.0	Participation rate: 98%. Analysis stratified by gender and age.
				Period prevalence: 9%	Period prevalence: 3%	2.9	0.4-21.4	Higher exposure jobs (HE) were located in the receiving, evisceration, whole bird grading, cut up and deboning departments. Lower exposure jobs (LE) were located in the maintenance, sanitation, quality assurance and clerical departments.
			Point prevalence: Based on symptom and physical exam using standard diagnostic criteria. Case must fulfill symptom definition listed above.	Point prevalence: 4%	Point prevalence: 3%	1.3	0.2-11	Examiners blinded to case and exposure status.
			Exposure: Observation and walkthrough; jobs categorized as high exposure and low exposure based on observed force and repetition of hand maneuvers.	Plant #2: (High exposure) Any symptoms: 42%	Plant #2: (Low exposure) Any symptoms: 11%	OR= 3.9	1.5-10.2	30% of workers in job rotation program may influence associations.
				Period prevalence: 5%	Period prevalence: 3%	1.8	0.2-15.2	Annual turnover rate -50% at plant 1 and 70% at plant 2; making survivor bias a strong possibility.
				Point prevalence: 1%	Point prevalence: 0%	õ õ	õ õ	

(Continued)

Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Knave et al. 1985	Cross-sectional	400 VDT operators from 4 industries using VDTs >4 hr/day; compared to 157 office employees without VDT work at the same industries.	Outcome: Questionnaire—symptom questionnaire based on frequency and intensity scores: negligible=1, slight=2, pronounced=3. Exposure: Based on self-assessment "hrs of typing." A special gaze direction instrument recorded time spent looking at VDT screen. Observation was conducted but not included in analysis.	Results estimated from histogram: Rt. side of neck: 5% Lt. side of neck: 20%	Results estimated from histogram: Rt. side of neck: 5% Lt. side of neck: 0%	õ õ Typing hr significantly related to neck symptoms. Dose-response relationship found between registered work duration and musculo-skeletal complaints.	õ õ	Participation rate: Initially exposed 97%; referent 100%; Phase IV exposed 84% referents 84%. Cases and referents matched on age and gender. Musculoskeletal complaints grouped in analysis; because of large number of comparisons, some without *a prior* hypotheses, reliable conclusions limited to $p<0.001$. Significant difference between females and males in reported neck symptoms. No statistical difference between cases and referents in discomfort scores, but "tendency towards higher discomfort scores for shoulder, neck, and back among the exposed group." No difference in cases and referents in whether work was "interesting" or they had a "positive attitude" towards work. Age, smoking, educational status, and drinking did not correlate with symptoms. Females reported more symptoms than males in both referent and case groups. 'Registered' total work hr associated with musculoskeletal symptoms $p<0.05$.

(Continued)

Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Kukkonen et al. 1983	Cross-sectional/ Inter-vention	104 female data entry workers. 60 data entry operators (noted as "study group") were grouped with 44 data entry operators who worked at another bank and were compared with 57 female workers in varying office tasks.	Outcome: Questionnaire—stiffness and pain in the neck and shoulder region, frequency of symptoms and localization. Physical exam (PE): A clinical functional examination performed by a physiotherapist. Exposure: Observation of posture, movements and working techniques, assessment of characteristics of desk, chair, equipment, interview with foremen and workers to get determination of physical, mental, and social environment at workplace. Foremen and workers were interviewed so that the organization of work and the physical, mental, and social environment at the workplace could be determined.	Data entry groups: 47% Tension neck syndrome in study group pre-interven-tion: 54% Tension neck syndrome in study group post-interven-tion: 16%	28% Tension neck syndrome in data entry comparison group pre-interven-tion: 43% Tension neck syndrome in data entry comparison group post-interven-tion: 45%	2.3	1.1-4.6	Participation rate: Not reported. Examiners blinded to case status. No adjustment for confounders. Examiner blinded to case status. Average duration of employment 3.5 years. Intervention consisted of: Adjustment of desk, chairs, data processing equipment individually to suit each worker, who was instructed to carry out adjustments herself. Document holders were added. The study group was given a short course of basic training on pertinent aspects of ergonomics. Four lessons on relaxation was given by means of exercises. Physiotherapy was given to workers for whom the doctor prescribed—17 from the study group and none from the first reference group had treatments.

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Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Kuorinka and Koskinen 1979	Cross-sectional	93 scissor makers, (n=90 females, 3 males) compared with 113 female department store shop assistants from Luopäjarvi's 1979 study. Excluded those with seropositive rheumatic affections as well as cashiers.	Outcome: Symptoms and physical examination—two tender spots symptoms of neck stiffness and fatigue/ weakness and/or palpable hardenings + muscle tenderness in neck movements. Physiotherapist examined workers, diagnoses were from predetermined criteria [Waris 1979]. In problem cases orthopedic and physiatric teams handled cases. Exposure: Based on job analysis from work history of previous year from production and salary forms. Conducted record review of hr worked/task, production statistics, absences: used only cases where 80% of hr cross-checked (n=76). Work methods for each type of station analyzed. Stations classified according to dominance of inspection or manipulation of scissors, and length of cycle using observation and video-taping. Observations made looking at hand/wrist force, repetition and hand grasp. Calculated index for wrist deviation. —Work methods for each work station analyzed: Cycle time. —Total workload during investigation/year recorded individually as pieces handled.	61%	28%	Scissor makers vs. referents: OR=4.1 Short cycle tasks vs. long-cycle tasks and tension neck syndrome: OR=1.64	2.3-7.5 0.7-3.8	Participation rate: 81%. 99% female study group, no significant age difference. Used Waris [1979] criteria for examination which called for blinding of examiners, otherwise it was not mentioned. No association between tension neck syndrome and: (1) age, (2) duration of employment, and (3) weight/height^2. Total workload for the number of pieces handled in one year significantly associated with tension neck syndrome Although authors state no relationship between short cycled and longer cycled tasks; both groups of tasks would be classified as highly repetitive using Kilbom, Silverstein's and other criteria. Lack of variance in comparison groups. Authors noted: "earlier unpublished questionnaire pertaining to activities outside factory — extra work, hobbies, did not indicate correlations with work..." Found that "diseases" seem to accumulate in same individuals. Physical workload was low. A slight trend towards tension neck being more common in manipulation tasks than in inspection but not statistically significant.

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Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Linton 1990	Cross-sectional	22,180 employees undergoing screening examinations at their occupational health care service in Sweden. 85% of the Swedish workforce is covered by health care services. Cases compared to "non-cases" defined by outcome. Groups selected *a priori* which would represent exposure as well as little or no exposure for psychosocial variables.	Outcome: Cases defined from questionnaire responses as those persons reporting "yes" to having seen a health care professional for neck pain in the last year. Exposure: Based on questionnaire responses—questions asked regarding heavy lifting, monotonous or assembly line work, sitting, uncomfortable work postures (bending or twisting), vibration. Psychosocial work environment: Work content, workload, social support.	18% had seen health care profes-sional for neck pain 31% had experi-enced neck pain	Õ Õ	Monotonous work and poor psychosocial environment: OR = 3.6 Lifting and poor psychosocial environment: OR=2.7 Uncomfortable posture and poor psychosocial environment: OR=3.5	2.8-4.6 2.0-3.6 2.7-4.5	Participation rate: Authors had access to all workers' records; 85% of working population has occupational health care services. Analysis stratified for age, gender. Lifestyle factors asked: Exercise, eating, smoking, alcohol consumption. On univariate analysis, heavy lifting, monotonous work, uncomfortable posture, and vibration had elevated ORs. Sitting did not. On univariate analysis, eating regularly and smoking had elevated ORs. Alcohol and exercise did not. Authors caution direct comparison of ergonomic and psychosocial variable's ORs. The scales were not consistent for the different factors measured.

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Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Liss et al. 1995	Cross-sectional	1,066 of 2,142 dental hygienists from Ontario Canada Dental Hygienists Association compared to referent group, 154 of 305 dental assistants who do not scale teeth.	Outcome: Mailed survey, case definitions based on Nordic Questionnaire, percent reporting neck symptoms >7 days in past 12 months. Exposure: Based on mailed survey and self-reported answers—length of practice, days/week worked, patients/day, patients with heavy calculus, percent of time trunk in rotated position relative to lower body, instruments used, hr of typing/week, type of practice.	43%	30%	1.7 Had to modify their work or were unable to work at some point, (hygienists compared to dental assistants): OR=2.4	1.1-2.6 1.1-5.4	Participation rate: 50% from both groups. Study population >99% female. No association with duration of employment. Not controlled for confounders. Very low response rate, confounders not considered, study has methodologic problems which influence interpretation of results.

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Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	RR, OR, or PRR	95% CI	Comments
Luopäjarvi et al. 1979	Cross-sectional	Assembly line workers (n=152 females) compared to shop assistants in a department store (n=133 females). Cashiers excluded from comparison group.	Outcome: Tension neck syndrome (TNS): Neck stiffness and fatigue/weakness and two tender spots and/or palpable hardenings + muscle tenderness in neck movements. Exposure: Observation, video analysis, and interviews used to assess exposure to repetitive arm work, static muscle work affecting neck/shoulder area.	37%	28%	TNS: OR=1.56 Had seen a doctor for neck symptoms: OR=4.38	0.9-2.7 2.1-9.24	Participation rate: 84%. Workers excluded from participation for previous trauma, arthritis and other pathology. No difference in mean ages between exposed and referents. Examined only females. Factory opened only short time so no association between duration of employment and MSDs possible. Social background, hobbies, amount of housework not significant.

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Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Milerad and Ekenvall 1990	Cross-sectional	99 dentists randomly selected from Stockholm dentist registry who practiced $ 10 years compared to 100 pharmacists selected from all pharmacists in Stockholm.	Outcome: Based on telephone questionnaire. Neck symptoms at any time before the interview ("lifetime prevalence"). Further analyzed according to Nordic questionnaire as to duration during last 12 months and during last 7 days, effect on work performance and leisure activities, and sick leave. Exposure: Based on questionnaire. Exposures included: (1) abduction of arm particularly in sit-down dentistry; (2) work hrs/day; and (3) static postures.	54% Male: 45% Female: 63%	Pharma-cists: 26% Male: 18% Female: 32%	2.1 2.6 2.0	1.4-3.1 1.2-5.0 1.3-3.1	Participation rate: 99%. Analysis stratified by gender. No difference in leisure time exposure, smoking, systemic disease, exposure to vibration. Symptoms increased with age in female dentists only. Duration of employment highly correlated with age: dentists (r=0.84), pharmacists (r=0.89). No relation between symptoms and duration of employment. Equal problems dominant and nondominant sides. Genders "equally prone to develop neck symptoms when subjected to equal work-related musculoskeletal strain." No analysis of exposure factors. Only discussion of "probable reasons" for high risk using work positions, flexing neck.

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Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

				MSD prevalence				
Study	**Study design**	**Study population**	**Outcome and exposure**	**Exposed workers**	**Referent group**	**RR, OR, or PRR**	**95% CI**	**Comments**
Ohlsson et al. 1995	Cross-sectional	Industrial Workers (n=82 females) exposed to repetitive tasks with short cycles mostly far <30 sec, usually with a flexed neck and arms elevated and abducted intermittently; 68 former workers (mean employment time 21 years) who had left the factory during the seven years before the study; these workers were compared to 64 referents with no repetitive exposure at their current jobs.	Outcome: Pain in the last 7 days and physical exam (PE) diagnosing tension neck syndrome, cervical syndrome. Tension neck: Tightness of muscles, tender spots in the muscles. Cervical syndrome: Limited neck movement, radiating pain provoked by test movements, decreased sensibility in hands/fingers; muscle weakness of upper limb. Exposure: Videotaping and observation. Analysis of postures, flexion of neck (critical angles 15E and 30E). 74 workers videotaped $10 min from back and sides. Average counts of two independent readers for frequencies, duration, and critical angles of movement used. Repetitive industrial work tasks divided into 3 groups: (1) fairly mobile work, (2) assembling or pressing items, and (3) sorting, polishing and packing items Weekly working time, work rotation, patterns of breaks, individual performance rate (piece rate). Only exposure readings from right arm were used.	Tension neck: 40% Cervical syndrome: 1%	Tension neck: 13% Cervical syndrome: 0%	Tension neck syndrome (industrial workers compared to referents): OR=3.6 Õ	1.5-8.8 Õ	Participation rate: Current workers: 96%; past workers: 86%; referents: 100%. Controlled for age. No exposure information available to examiners, "not possible to completely blind the examiners." Questionnaire included individual factors, work/environment, symptoms, psychosocial scales. Muscle strength measured by (maximum voluntary capacity) at elevation, abduction, and outward rotation of both arms measured by dynamometer. Videotape analysis revealed considerable variation in posture even within groups performing similar assembling tasks. Logistic models replacing repetitive work with videotape variables found muscular tension tendency and neck flexion movements significantly associated with neck/shoulder diagnoses. Inverse relationship between duration of industrial work and MSDs, largest OR employed <10 years. Assembly group has high OR (6.7) with regard to neck/shoulder MSD compared to referents. Significant association between time spent in neck flexion positions < 60E.

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Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	RR, OR, or PRR	95% CI	Comments
Ohlsson et al. 1989	Cross-sectional	Electrical equipment and automobile assemblers (n=148), 76 former female assembly workers who quit within 4 years compared to 60 randomly sampled female from general population.	Outcome: Determined by questionnaire—any neck pain, neck pain affecting work ability, and neck pain in the last 7 days and the last 12 months. Exposure: Based on job categorization and questionnaire—number of items completed/hr. Work pace divided into four classes: (1) slow: <100 items/hr; (2) medium: 100 to 199 items/hr; (3) fast: 200 to 700 items/hr; (4) very fast: >700 items/hr.	Pain in last 12 months: 39% Work inability in last 12 months: 13% Pain in last 7 days: 21%	Pain in last 12 months: 32% Work inability in last 12 months: 7% Pain in last 7 days: 17%	1.9 2.8 1.9	0.9-3.7 0.9-8.8 0.7-3.6	Participation rate: Not reported. For younger females, increase in pain occurred with increased duration of employment. OR increased with increasing work pace, except for very high paces, which there was a decrease. Logistic models checked for interaction and controlled for age. Study group consisted of females only. Significant association between symptoms and duration of employment much stronger for workers <35 years old than workers >35 years old.

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Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Onishi et al. 1976	Cross-sectional	The following were compared to 101 female office workers: Film rolling workers: 127 (females). Subjects categorized as: Group I: Without symptoms of cervico-brachial disorder. Group II: Subjective symptoms in the neck, shoulder, or upper limbs. Group III: Symptoms and clinical signs.	Outcome: Based on (1) symptoms of neck stiffness, dullness, pain, numbness; (2) pressure (<1.5 kv/cm²) measured by strain transducer at which subject felt pain; (3) physical exam: range of motion, tests, nerve compression tenderness. Exposure: Observation of job tasks, then job categorization. Film rollers wind 1 roll of 35 mm film every 2.5 to 5 sec over 7.5 hr/day. Loading of trapezius was examined in two workers during work activities by electromyography.	Group I: 29% Group II: 39% Group III: 23%				Participation rate: Not reported. Body weight, weight skin fold thickness, muscle strength and grip strength obtained. Body height and weight differences not statistically significant. No difference between workers with tenderness threshold above 1.5 kg/cm² and those below with respect to age, height, weight, skin fold thickness, grip strength, upper arm abduction strength, back muscle strength. Authors noted that continuous loading of the trapezius seems characteristic to repetitive operations where the upper limbs are used.

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Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Ryan and Bampton 1988	Cross-sectional	Data process operators (n=143). Group with highest scores (n=41) designated "cases," compared to lowest scores (n=28).	Outcome: Symptoms (pain, ache, sore, hurts, numb, swollen, etc.) occurring $3 times/week with no physical exam signs or $ weekly with physical exam signs of muscle tenderness present; diagnosed "myalgia" as diffuse muscle pain and tenderness. Exposure: Ergonomic assessment measuring angles and distances of each operator seated at his/her workstation. Wrist extension, ulnar deviation, elbow angle, shoulder abduction, and shoulder flexion were measured. Also measured: person and furniture fit, eye-copy and eye-keyboard fit, elbow-keyboard height difference, popliteal-chair height difference, and copy placement.	Shoulder: 44% symptom only Neck: 43% symptoms only Neck/ shoulder symptoms occurring $ 3 times weekly with no signs or weekly with signs: 44%	õ õ	Not reported	õ õ	Participation rate: 99%. Interviewers blinded to questionnaire responses. No adjustment for confounders; cases for analysis were those with either neck, shoulder, or lower arm scales having higher symptom scores compared to those with low scores. Cases had higher visual glare index, feeling there was insufficient time for rest breaks, more boredom, more work stress, and needed to push themselves >3 times/week; lower peer cohesion, autonomy, clarity. Higher staff support and work pressure. Significant differences in those trained in adjustment of their chairs. No differences for height, weight, age, marital and parental status, handedness, time in current job, time spent keying or typing, whether this was their first job, length of training time. Significant difference in smaller mean elbow angle and shoulder flexion of the left arm, and smaller eye-copy distance.

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Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	95% CI	Comments
Sakakibara et al. 1987	Cross-sectional	Orchard workers (n=48, 20 males and 20 females). Compared symptoms after completion of thinning of pears, bagging of pears and bagging of apples (covering fruit with paper bags while on the trees). Internal comparison using same study population.	Outcome: Shoulder pain described as the presence of stiffness and pain daily. Exposure: Observation of jobs. Angles of flexion of the shoulder and extension of the neck on one subject were measured every 25 min during a whole day doing each task. No observation was made on neck repetition. Farmers worked approximately 8 hr/day for 10.6 to 13.6 days each year bagging or thinning pears and bagging apples.	Estimated from histograms Pears: Rt. side: 20% Lt. side: 20%	Estimated from histograms Apples: Rt. side: 9% Lt. side: 9%	 p<0.05 p<0.01	õ õ	Participation rate: 77%. Stratified by gender. General fatigue, gastric disturbances, appetite loss and headache showed no difference in frequency between tasks. Exposure data based on measurement of one worker may not be generalized to others. The angle of forward flexion in the shoulder and that of extension in the neck was statisticallly significantly positively correlated (r=0.88, p#0.01). The proportion of workers with >90E forward shoulder flexion was significantly higher for thinning out pears and bagging pears than for bagging apples. The authors presumed that the symptoms of dizziness and tinnitus may be associated with the cochlear-vestibular symptoms of vertebral insufficiency due to continuous extension of the head. Results presented in paper in histograms.

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Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Sakakibara et al. 1995	Cross-sectional	Of 65 female Japanese farmers. 52 completed the questionnaire and physical exam in late June for bagging pears and late July for bagging apples.	Questionnaire: Stiffness and pain in neck region. Symptoms in past 12 months for $one day, or symptoms in past 12 months for $8 days. Exam: Pain in motion of the neck joint such as flexion/extension, lateral bending, and rotation. Exposure: Observation of tasks and measurements of representative workers (only two workers measured) . Angle of arm elevation during bagging was measured in one subject.	Pear bagging Neck pain=40% Neck pain in joint motion: 55.8%	Apple bagging Neck pain=25% Neck pain in joint motion: 36.5% controls	Workers bagging pears with neck pain vs. apple bagging with neck pain, *p*<0.05 Workers bagging pears with pain in joint motion vs. apple bagging with pain in joint motion: PRR=1.5	0.99-2.35	Participation rate: 80%. Examiners not blinded to case status due to design of study. Same population examined two times. 2nd exam occurred one month after first. These results used in analyses for comparison of two tasks. Stiffness and pain during apple bagging may have been pain that was a residual of pear bagging operations. Number of fruit bagged/day was significantly more in pear bagging than in apple bagging. Exposure measurements only obtained on 2 workers and generalized to all workers.

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Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	Referent group	RR, OR, or PRR	95% CI	Comments
Schibye et al. 1995	Cohort	Follow-up of 303 sewing machine operators at nine factories representing different technology levels who completed questionnaire in 1985. In April 1991, 241 of 279 traced workers responded to same 1985 questionnaire. Operators still working were compared to those who moved to other employment in 1991.	Outcome: Nordic Questionnaire— discomfort, ache, or pain in the neck during the previous year; whether they had neck pain in last 7 days, and whether pain prevented them from doing daily duties. Exposure: Assessed by questions regarding type of machine operated, work organization, workplace design, units produced/day, payment system, and duration of employment as a sewing machine operator.	Neck symptoms in previous year for employees maintaining a piece-work groups of <100 units/day: 36% Neck symptoms in previous year for employees maintaining a piece-work groups of 100 to 125 units/day: 53% Neck symptoms in previous year for employees maintaining a piece-work groups of >125 units/day: 61%		Developing neck symptom improvement in 1991 among operators compared to other employment group OR=0.85 Neck symptom improvement in other employment group vs. operator group: 12 month symptoms: OR=3.3 7 day symptoms: OR=3.9	0.29-2.4 1.4-7.7 1.3-11.9	Participation rate, 1985: 94%. Participation rate, 1991: 86%. All participants were female. 77 of 241 workers still operated a sewing machine in 1991. 82 workers had another job in 1991. Among those 35 years or below, 77% had left job; among those above 35 years, 57% left job. 20% reported musculoskeletal symptoms as the reason for leaving job. No significant changes in prevalences among those employed as sewing machine operators from 1985 to 1991; significant decrease in those who changed employment. As many as 50% of respondents reported a change in the response to positive or negative symptoms from 1985 to 1991. Operators always working at the same machines showed significantly higher neck symptoms compared to those working at different machines Although the authors state that the analysis did not show the development of neck (or shoulder) symptoms among workers who had worked as a sewing machine operator to be significantly related to exposure, exposure time, or age, there was a significant drop-out rate of those above 35 years.

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Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Veiersted and Westgaard 1994	Cohort	30 female chocolate manufacturing workers. 17 who contracted trapezius myalgia within 6 to 51 weeks compared to those workers without.	Outcome: Trapezius myalgia—neck and shoulder pain lasting >2 weeks of a degree making it difficult to continue work. At least one tender or trigger point present. Prospective interviews every 10 weeks to detect symptoms of muscle pain. Daily "pain diaries" kept by subjects. Exposure: Static muscle tension during work was between 1 and 2% of maximal voluntary activity of the trapezius muscles recorded by electromyographic measurements of trapezius muscle in earlier study. Interviews conducted prospectively every 10 weeks concerning exposure at work for 1 year.	56%	õ õ	Perceived strenuous postures: OR=7.2 Physical environment: OR=0.9 Psychosocial factors: OR=3.3 Perceived strenuous previous work: OR=6.7	2.1-25.3 0.5-1.7 0.8-14.2 1.6-28.5	Participation rate: 55%. Drop-out rate may limit generalizability of results although drop-outs did not differ in exposure estimates and complaints. Excluded subjects with: (1) no similar occupation during last 5 years; (2) known musculoskeletal disorder predisposing for myalgia; (3) neck or shoulder pain sufficient to initiate medical visit, (4) if employed <26 weeks. Several anthropometric, non-work-related, general health, personality, psychosocial, and previous employment variables included in initial interview and follow-ups. Subjects on a fixed-wage system. Work was mainly machine-paced. Nine of 17 with trapezius myalgia had sick leave after medical consultation. No difference in general health status, anthropometric measures. None of the models showed any effect of the "physical environment." Parameters which included exposure to draft, vibration (floor or machine), or noise. Observation time was considerably shorter for workers who contracted neck pain compared to status used in analysis. Non-patients had more opportunities to report a positive answer. The perceived strenuous postures were not reflected in any of the conventional EMG parameters (static, median or peak loads).

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Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Viikari-Juntura et al. 1994	Cohort longitudinal; 2 questionnaires 3 years apart	688 machine operators and 553 carpenters compared to 591 office workers. All male.	Outcome: Neck trouble, categorized on 5 point scale ("not any" to "daily"). Exposure: Based on job category. Machine operators—static work with whole body vibration, carpenters—dynamic physical work, office workers—sedentary work. For initial evaluation, observation of work sites were performed.	12 month prevalence for severe neck pain for 1984/1987 Machine operators: 28/40% Carpenters: 25/32% Office workers: 9/12%	õ õ	Carpenters vs. office workers: No neck pain to moderate: OR=1.6 No neck pain to severe: OR=1.6 Persistently severe: OR=3.0 Machine operators vs. office workers: No neck pain to moderate: OR=1.8 No neck pain to severe: OR=3.9 Persistently severe: OR=4.2	 1.0-2.5 0.8-3.0 1.4-6.4 1.1-2.8 2.3-6.9 2.0-9.0	Participation rate: 81% machine operators; 79% carpenters; 89% office workers. Adjusted for occupation, smoking, and physical exercise, age, duration or current occupation. 2% had retired. In multivariate analysis; “occupation” was only significant predictor in change from no neck trouble to moderate neck trouble. Twisting or bending trunk not a significant predictor of neck pain. In multivariate analysis: occupation, age, and current smoking were significant predictors in change from no neck trouble to severe neck trouble. Interaction between age and occupation not significant. Job satisfaction not associated with neck trouble and other predictors.

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Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

				MSD prevalence				
Study	Study design	Study population	Outcome and exposure	Exposed workers	Referent group	RR, OR, or PRR	95% CI	Comments
Welch et al. 1995	Cross-sectional	39 of 47 sheet metal workers attending a screening for occupational lung disease. Cases compared to those without symptoms.	Outcome: Symptom survey; pain, aching, stiffness, burning, numbness or tingling in neck $ once/month, or lasting > one week, no history of previous traumatic injury. Symptoms began after working as a sheet metal worker and prior to retirement. Exposure: Questionnaire survey obtaining types of tasks performed, tools used, frequency of task performance. Hanging duct work dichotomized into > and <40% of time worked.	21%	Comparison group with no symptoms	Percent time hanging duct: OR=7.5	0.8-68	Participation rate: 83%. Smoking cigarettes, average number of years working not found to be significantly different between symptomatic and asymptomatic; other confounders (age, gender) not mentioned. Average length of employment in trade: 33 years. Pilot study. Hrs/week using hand tools, percent of time in the shop vs. time in the field not significant. Duration of employment not included in article.

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Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Wells et al. 1983	Cross-sectional	196 male letter carriers compared to 203 male meter readers and postal clerks. 104 letter carriers had weight increased from 25 to 35 lbs. in the year prior to the study.	Outcome: Telephone interview case status based on current pain; frequency, severity, interference with work, etc.; score of 20 required to be a case—more points given to neck and shoulder problems that interfered with routine daily activities. Exposure: Based on job category; based on self-reported information on weight carried, previous work involving lifting and work-related injuries.	All letter carriers: 12% Letter carriers with increased weight: 12% Letter carriers with no weight increase: 12%	Postal clerks: 5% Meter readers: 7%	All letter carriers vs. clerks and readers: OR=2.57 Letter carriers with increased weight vs. clerks: OR=2.63 Letter carriers with no weight increase vs. clerks: OR=2.87	1.13-6.2 0.9-8.8 0.9-9.8	Participation rate: 99% among letter carriers, 92% meter readers, 97% postal clerks. No significant difference in schooling and marital status. Comparison group (gas meter readers) used because of similar "walking rate" without carrying weight compared to letter carriers. Postal clerks neither walk nor carry weight. More weight given to scoring neck and shoulder. Outcome influenced results when ranking of body MSDs though would not influence group comparisons. Adjusted for age, number of years on the job, Quetelet ratio and previous work experience. Study limited to males. Letter carriers with increased bag weight walked on average 5.24 hr; those with no change in bag weight walked 4.83 hr. Letter bag straps usually carried on the shoulder.

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Table 2–7 (Continued). Epidemiologic studies evaluating work-related neck musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Yu and Wong 1996	Cross-sectional	151 VDT users from an international bank in Hong Kong; of these 90 were data entry, data processing, computer programmers; 61 infrequent users of VDTs.	Outcome: Questionnaire survey used to collect information on discomfort or ache during work after starting the current job. Exposure: Questionnaire survey on "undesirable postures" including frequent bending of the back and inclining the neck forwards.	31.4%		Frequent users of VDTs vs. infrequent users: *p*=0.0025 Logistic model for neck pain inclining neck at work: OR=784.4 Fixed keyboard height: OR=90.1 Frequent VDT use: OR=28.9 Female gender: OR=1.6 Age (years): OR=1.2	 33.2-18,630 7.6-1056 2.8-291.8 0.35-6.8 1.02-1.5	Participation rate: 80%. Ages ranged from 18 to 41 years, 74% between 21 to 30 years. Analysis controlled for "age and gender, and other covariates." Queried about personal particulars, job nature and characteristics, working posture, general health conditions. Males with significantly longer mean VDT working experience compared to females (5 vs. 2.7 years). Non-workplace factors not examined.

Table 2–8. Epidemiologic studies evaluating work-related neck/shoulder disorders

				MSD prevalence				
Study	Study design	Study population	Outcome and exposure	Exposed workers	Referent group	RR, OR, or PRR	95% CI	Comments
Åaras 1994	Prospective	15 female assembly workers making telephone exchanges. 27 female VDT users. 25 female data entry operators. 29 male VDT users.	Outcome: Assembly Workers: musculoskeletal sick leave/man-labor years; pre- and post-intervention. Data Entry and VDT Users: Survey: Pain intensity for the neck and shoulder region according to Nordic questionnaire. Exposure: Load on trapezius as measured by EMG. Quantification of the muscle load done by ranking the interval estimate (0.1 s) to produce an amplitude probability distribution function. Both total duration and number of periods/min. when muscle activity was below 1% MVC were calculated. Intervention: Replacing workstands with fixed heights to workplaces easily adjustable for both sitting and standing. Hand tools were counter- balanced and adjustable arm rests introduced. For VDT operators, tables and chairs adjusted to give more relaxed position of the shoulders, operators given more work surface for keyboard and mouse, and distances between operators and screen/documents adjusted.	Number of musculoskeletal diagnoses: pre-intervention, 1967 to 1974: 52 (30.6%) Number of musculoskeletal diagnoses post-intervention, 1975 to 1982: 35 (14.3%)		Duration of sick-leave/man-labor year (days) Median sick days pre-intervention: 22.9 Median sick days post-intervention: 1.8 Shoulder pain intensity: 3.4 2.2	4.4-50.8 0-34.4 2.3-4.4 1.3-3.3	Participation rate: Not reported. Study designed to evaluate if there is a relationship between trapezius load and incidence of MSD. Other intervening variables that may have reduced symptoms or sick leave were not discussed. Mean static trapezius load in assemblers was reduced from 4.3% MVC to 1.4% (post-intervention); mean static trapezius load in VDT users reduced from 2.7% MVC to 1.6% MVC (post-intervention). The mean intensity and duration of neck pain showed no significant reduction after intervention in the data dialogue females.

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Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

				MSD prevalence				
Study	**Study design**	**Study population**	**Outcome and exposure**	**Exposed workers**	**Referent group**	**RR, OR, or PRR**	**95% CI**	**Comments**
Andersen and Gaardboe 1993a	Cross-sectional	701 female sewing machine operators, compared to 781 females from the general population of the region and internal referent group of 89 females from the garment industry.	Outcome: Case of chronic neck pain was defined as continuous pain lasting for a month or more after beginning work and pain for $ 30 days within the past year. Exposure: Categorization broken down according to current occupational status by job title. Classification into exposure groups based on author's experiences as occupational health physicians and involved crude assessment of exposure level and exposure repetitiveness. High exposure jobs were those involving high repetition/high force or high repetition/low force or medium repetition/high force. Medium exposure jobs were those involving medium repetition/low force and low repetition and high force. Low exposure jobs were low repetition/low force. For the analysis, "length of employment as a sewing machine operator" was considered the variable of interest, the rest were confounders.	34.2%	General population: 12.9% Internal referent group: 10.1%	Sewing machine operators compared to: (1) General population: OR=3.5 (2) Internal referent group OR=4.6 Logistic model Years as sewing machine operator (0 to 7 years): OR=3.17 (8 to 15 years): OR=11.2 (>15 years): OR=36.7 Age >40 years: OR= 1.96 Current high exposure (-/+): OR=0.32 Children (>0): OR =0.35 Exercise (-/+): OR=1.28 Smoking (=/-): OR=2.3	2.6-4.7 2.2-10.2 0.6-16.1 2.4-52.3 7.1-189 0.8-5 0.1-1 0.1-1.9 0.5-3.4 0.9-6.1	Participation rate: 78.2%. Examiners blinded to case status. Respondents excluded if had previous trauma to neck, shoulder, or arms or had inflammatory disease at time of response. Odds ratios adjusted for age, having children, not doing exercise, socioeconomic status, smoking, and current neck/shoulder exposure. Age-matched exposure groups and controls. Presented study as "general survey of health in the garment industry" to minimize information bias.

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Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Andersen and Gaardboe 1993b	Cross-sectional	From a historical cohort of 424 sewing machine operators, 82 were randomly selected and categorized by number of years of employment: 0 to 7 years, 8 to 15 years and greater than 15 years. These were compared to a referent group composed of 21, 25 and 36 operators from each group and 25 of 55 auxiliary nurses and home helpers who participated in the study.	Outcome: Measured by health interview and exam of the neck, shoulder and arm. Case of chronic pain was defined as continuous pain lasting for a month or more after beginning work and pain for $ 30 days within the past year. Physical examination: Restricted movements in the cervical spine and either palpatory tenderness in cervical segments or irradiating pain or tingling at maximum movements or positive foraminal test. Exposure: Exposure categorization broken down according to current occupational status by job title. Classification into exposure groups based on author's experiences as occupational health physicians and involved crude assessment of exposure level and exposure repetitiveness. High exposure jobs: Involved high repetition/ high force or high repetition/ low force or medium repetition/ high force. Medium exposure jobs involved medium repetition/ low force and low repetition and high force. Low exposure jobs were low repetition/low force.	50.9% Tension neck syndrome: 40% Cervical Syndrome: 20%	46.2%	Referents: OR=1 0 to 7 years: OR=2.3 8 to 15 years: OR=6.8 >15 years: OR=16.7 Age $ 40 years: OR=1.9 Children >0 years: OR= 0.5 Exercise: OR=1.4 Smoking: OR=1.5 Current high exposure: OR=1.6	 0.5-11 1.6-28.5 4.1-67.5 O.9-4.1 0.1-1.7 0.6-2.96 0.7-3.3 0.7-3.6	Participation rate: 78.2%. Logistic regression limited to a combined neck/shoulder case definition. Age-matched exposure groups and controls. Examiners blinded to control/subject status. Controlled for age, having children, not doing leisure exercise, smoking, socioeconomic status. Poor correlation between degenerative X-ray neck changes and cervical syndrome. Most frequent diagnosis among study group was "cervicobrachial fibromyalgia" significant for test of trend with exposure time in years. Chronic neck pain vs. palpatory findings: Sensitivity: 0.85; Specificity: 0.93.

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Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Bergqvist et al. 1995a	Cross-sectional	260 office workers using VDTs, (198 females); symptomatic cases compared to non-cases.	Outcome: Neck/shoulder discomfort: Any discomfort over the last 12 months; intense neck discomfort: As above, if occurred in last 7 days and interfered with work. Physiotherapist's diagnosis of (1) Tension neck syndrome: Ache/pain in the neck; feeling of tiredness and stiffness in neck; possible headache; pain during movements; muscular tenderness; (2) Cervical diagnoses: Ache/pain in neck and arm; headache; decreased mobility due to cervical pain during isometric contraction; often root symptoms such as numbness or parathesias. Exposure: Based on observation an ergonomic evaluation using data on each individual's most common work situations: Static work posture, nonuse of lower arm support, hand in non-neutral position, insufficient leg space at table, repeated movements with risk of tiredness, specular glare present on VDT. Measured: Height difference of VDT keyboard-elbow, High visual angle to VDT.	Neck/shoulder: 61.5% Female: 63% Male: 57%		Intensive neck/shoulder discomfort: stressful stomach reactions: OR=5.4 Repeated work movements: OR=3.6 Too highly placed VDT: OR=4.4	1.6-17.6 0.4-29.6 0.9-60.3	Participation rate: 92% of 353 office workers, of which 260 were VDT users. Adjusted for age and gender. Examiner and workplace investigators blinded to case and exposure status. Factors included in analysis: Age, gender, smoking, children at home, negative affectivity, tiredness-related stress reaction, stomach-related stress reaction, use of spectacles, peer contacts, rest breaks, work task flexibility, overtime, static work position, non-use of lower arm support, hand in non-neutral posture, repeated movements with risk of tiredness, height differences keyboard/elbow, high visual angle to VDTs, glare on VDTs. There are problems with interpreting results because of multiple comparisons and multiple models. Not all significant findings presented in paper.

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Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Bergqvist et al. 1995b	Cross-sectional	322 office workers from 7 Stockholm companies; VDT users compared to non-VDT users 52% interactive, 29% data entry, 19% non-VDT users.	Outcome: Neck/shoulder discomforts: Any discomfort over the last 12 months; intense neck/shoulder discomfort: As above, if occurred in last 7 days and interfered with work. Physiotherapist's diagnosis of tension neck syndrome: Ache/pain in the neck; feeling of tiredness and stiffness in neck; possible headache; pain during movements; muscular tenderness. Exposure: Video display terminal use: Based on self-reporting of VDT use. VDT users categorized into data entry or interactive VDT users. Ergonomic Factors: Same as Bergqvist 1995a.	Neck/shoulder discomfort: 60% Intense neck/shoulder discomfort: 7.4%		Neck/shoulder discomfort: Current VDT work vs. no VDT work: OR=1.4 For accumulated VDT work > 5 PY²: OR=1.3 Intense neck/shoulder discomfort: Current VDT work vs. no VDT work: OR=0.5 For accumulated VDT work >5 PY²: OR=0.8	0.8-2.4 0.7-2.5 0.2-1.8 0.3-2.5	Participation rate: 92% questionnaire; 91% physiotherapy exam; 82% workplace exam. Examiner and workplace investigators blinded to case and exposure status. Intensive neck/shoulder discomfort was associated with VDT work over 20 hr and having "stomach reactions" often and repetitive movements. OR=3.9 (1.1-13.8). Originally 535 workers queried in 1981, of those 182 had left the workplace (quit, retired, etc.)–possible bias from "Healthy Worker Effect." Covariates considered: Children at home, smoking, negative affectivity, stomach-related stress reactions, tiredness-related stress reactions; organizational factors considered limited or excessive peer contacts, limited rest break opportunity, limited work task flexibility, frequent overtime. For cervical diagnoses: Excess OR suggested for combined occurrence of VDT work of >20 hr/wk and specular glare on the VDT screen.

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Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Bjelle et al. 1981	Case-control	13 workers of industrial plant consecutively seen at health clinic with acute, nontraumatic neck/shoulder pain not due to causative disease or malformation compared to 26 controls. Matched on age, gender, and place of work.	Outcome: Physician diagnosed neck/shoulder pain. Exposure: Anthropometric and isometric muscle strength were tested with strain gauge instruments. Patients asked to perform their maximal efforts. Measurements made for the following contractions: Shoulder elevation at the acromion, abduction and forward flexion of the shoulder joints at neutral position, and semi-pronated. Grip strength measured by vigorimeter. Video recording of arm movements at work. Shoulder loads estimated from videos. Consisted of measuring the duration and frequency of shoulder abduction or forward flexion of >60E. Electromyography measurement of shoulder load during assembly work on 3 patients and 2 healthy volunteers. Muscular load level determination made by computer analysis of myoelectric amplitude.	6 with tendinitis	Controls without tendinitis	Cases had significantly longer duration and higher frequency of abduction or forward flexion than controls, 2.5/min. (*p*<0.001). Cases had significantly higher shoulder loads than controls. Median number of sick-leave days significantly different between cases and controls (*p*<001).		Participation rate: Not reported. Investigators completed the video analyses blinded to case status. Anthropometric data, age no difference between cases and controls. Isometric strength test: Controls significantly stronger in 6 of 14 tests but probably influenced by pain inhibition in cases. No significant difference in cycle time (9 vs. 12 min).

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Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Blåder et al. 1991	Cross-sectional	Of 224 sewing machine operators from 4 plants, 199 completed a symptom survey. Of 155 who reported shoulder or neck pain in the past 12 months, 131 were examined.	Outcome: Survey: Shoulder or neck pain in past 12 months. Exam: Tenderness on palpation, range of motion, pain during motion or isometric muscle contraction, active and passive range of motion was measured by use of a goniometer. Diagnoses were not made during the examinations, but test forms were later analyzed by criteria from Waris [1979]. Exposure: From questionnaire: employment duration, hr/wk. Plants selected by representatives of Swedish Labour Union familiar with work sites with similar loads.	Muscle tenderness: Acromioclavicular joint: 15% Biceps tendon: 35% Decreased ROM: 30% Acromioclavi-cular: 5%	ŏ	Age Nationality Employment duration Working >30 hr/wk	p <0.05 non-significant p <0.05 p <0.05	Participation rate: 89% for questionnaire, 87% for physical exam. Only those with symptoms given physical exam. Physicians and physiotherapist not blinded to symptom status. High rate of turnover in plant. Authors state that study involved control group taking into account psychosocial factors, but results not included in this article. Questionnaire included information on background, family situation, employment, job conditions, health. Physical exam occurred 1 to 3 months after questionnaire. In 3 consecutive years 147 sewing machine operators left this work in the factories. 48% answered follow-up questionnaire. (17% left because of neck problems contributing to decision to leave work.)

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Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Ekberg et al. 1994	Case-control	Study population were aged 18 to 59 years, had to have yearly incomes of SEK 45,000 and not been on sick leave for more than 2 months in past 6 months, not employed in large rubber industry in area. "Cases" had consulted a community physician for musculoskeletal disorders of the neck, shoulder, arm, or upper thorax during the study period from semi-rural community in southern Sweden. Cases had to have been ill immediately prior to physician visit and have been on sick leave at most less than 4 weeks. No trauma, infectious cause, accident, malignancy, rheumatic disease, abuse, or pregnancy. Controls were randomly selected from Swedish insurance registry.	Outcome: Self-administered questionnaire; a modified version of the Nordic questionnaire asking about musculoskeletal symptoms in the past 6 months. Questionnaire included background factors, age, gender, ethnic background, family situation, smoking habits, and exercise. Exposure: Assessed by questionnaire; seven determinants were: uncomfortable sitting position, uncomfortable standing position, physically demanding work, light lifting (less than 6 kg), repetitive movements demanding precision, work with lifted arms, and monotonous work position. Rating scales were based on average duration of hours per day of each item of exposure. 52 items on psychosocial work conditions reduced to 8 factors by factor analysis: psychological work climate, quality of work content, work pace, demands on attention, work planning, job security, job constraints, and work role ambiguity.	ŏ	ŏ	Female gender: OR=15.5 Immigrant: OR=28.3 Current smoker: OR=8.2 Repetitive Precision Movements: Low: OR=1 Med: OR=3.8 High: OR=15.6 Light Lifting: Low: OR=1.0 Med + High: OR=49.7 Lifted arms: Low: OR=1.0 Med: OR=5.9 High: OR=3.7 Work Pace: Low: OR=1 Med: OR=7.6 Rushed: OR=10.7 ORs for controls with MSD symptoms in both neck and shoulder and other body parts: Repetitive Precision Movements: OR=7.5 Light lifting: OR=13.6 Lifted arms: OR=4.8 Uncomfortable sitting positions: OR=3.6	90% CI used in this paper 3.4-71 3.1-257 2.3-29 0.7-20 2.2-113 9.0-273 0.9-37 0.4-30 1.6-36 2.2-52 2.4-23 4.8-39 1.3-18 1.4-9.3	Participation Rate: 73%. Logistic analysis adjusted for age, gender, smoking, having preschool children. Age and having preschool children were not significant factors. Ambiguity of work role, demands on attention and work content also statistically significant.

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Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Ekberg et al. 1995	Cross-sectional	637 of 900 residents between the ages of 18 to 59 years, with an average yearly income of $ $8000 U.S. dollars.	Outcome: Based on modified Nordic questionnaire; case defined as the presence of symptoms during the past 6 months. Exposure: 20 questionnaire items on physical work conditions which were factor analyzed. Self-reported perception of physical work environment factors considered: Uncomfortable sitting or standing position; physically demanding work; light lifting; repetitive movements demanding precision; work with lifted arms, monotonous work position. Questionnaire on work organization, work content and relations in the work situation.	Symptoms neck: Male: 33% Female: 53% Shoulder: Male: 35% Female: 40%	õ	Gender: OR=1.3 Immigrant Status: OR=1.3 Repetitive movements demanding precision: OR=1.2 High work pace: OR=1.2 Low work content lack of stimulation and variation: OR=1.3 Work role ambiguity: OR=1.2	1.1-1.5 1.0-1.6 1.0-1.3 1.0-1.3 1.1-1.5 1.0-1.3	Participation rate: 73%. Symptom responses in neck and shoulder correlated (r=0.56) and collapsed into one variable for the analyses. Age, smoking, exercise habits, family situation with preschool children not significantly associated with symptoms. Social work climate, demands on attention, work planning, job security and job constraints not significantly associated with symptoms.

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Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Holmström et al. 1992	Cross-sectional	Of 2500 construction workers randomly selected from 4,159 active members of trade union registry of the south of Sweden, 1,773 (71%) participated. This group was represented by all construction trades except painters, electricians and plasterers. All participants must have worked in the past 6 months, including short periods of sick leave or unemployment.	Outcome: Self-reported history of musculoskeletal problems was obtained through a mail survey. Case of “neck and shoulder pain” defined as: Pain, ache, discomfort from the neck/shoulder are experienced sometimes often or very often during the past 12 months. Case of “considerable neck and shoulder pain” defined as neck and/or shoulder trouble with “severe” or “very severe” functional impairment. Exposure: Data on physical workload, psychosocial factors and individual and employment related factors obtained from mail survey.	Hands above shoulder <1 hr/day 1 to 4 hr/day >4 hr/day Hands at waist <1 hr/day /1 to 4 hr/day >4 hr/day Stooping <1 hr/day 1 to 4 hr/day >4 hr/day Kneeling <1 hr/day 1 to 4 hr/day >4 hr/day Sitting <1 hr/day 1 to 4 hr/day >4 hr/day Roofers Plumbers Floor Machines/ Tools.	—	1.1 1.5 2.0 1.0 1.1 1.2 1.0 1.4 1.5 1.4 1.4 1.5 0.6 1.6 0.7 1.6 1.5 1.3 1.1	0.8-1.5 1.2-1.9 1.4- 2.7 0.7-1.3 0.9-1.3 0.8-1.6 0.8-1.3 1.1-1.8 1.1-2.1 1.1-1.8 1.1-1.8 1.1-2.1 0.3-1.0 0.9-2.7 0.4-1.2 — — — —	Participation rate: 71%. Neck/shoulder pain related to increasing age, smoking, weight inactivity during free time, height under 185 cm. Controlled for age, physical factors. Dose-response relationship for working with hands above shoulder level. Stress index showed a dose-response. Stress questions pertained to rushing, job pressure, and inability to relax. Psychosocial factors strongly associated with neck and/or shoulder trouble and neck and shoulder pain when age and physical factors kept constant in logistic models for psychosocial pre-rate ratio, “high” level compared with “low” level for considerable neck pain; the following psychosocial scales were significant: Qualitative demands: 1.4 (1.0-2.0) Quantitative demands: 3.0 (2.1-4.0) Solitary work: 1.5 (1.2-1.8) Anxiety (health): 3.2 (2.5- 4.0) Psychosomatic: 5.0 (3.6-6.9) Psychological: 4.7 (3.6-6.0) Stress: 3.4 (2.6-4.2) The following were not significant: Discretion, support, under-stimulation, anxiety (work), job satisfaction, quality of life.

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Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

				MSD prevalence				
Study	Study design	Study population	Outcome and exposure	Exposed workers	Referent group	RR, OR, or PRR	95% CI	Comments
Hünting et al. 1981	Cross-sectional	VDT users: 53 data entry; 109 conversational VDT users; 78 typists; compared to 55 "traditional office workers" not using VDTs or typewriters.	Outcome: Questionnaire: Symptoms of pain, stiffness fatigue, cramps, numbness, tremor scaled as: Daily, occasionally, seldom, never; Medical Exam: Included an anamnesis and palpation of painful pressure points and tendons and tendon insertion points in the shoulders, arms, and hands. Exposure: (1) Questionnaire, (2) Observation and measurements of work-station, and (3) Body posture measured using method described by Hünting et al. 1980b.	Medical findings in shoulder and neck: Conversational VDT users: 28% Typewriter: 35% Data Entry terminal VDT users: 38%	Medical findings in shoulder and neck: Traditional office workers: 11%	Medical findings: Conversational terminal VDT users vs. trad. office workers: OR=1.35 Typewriter vs. trad. office workers: OR=3.18 Data entry terminal users vs. trad. Office workers: OR=9.9	 0.6-3.1 1.3-2.6 3.7-26.9	Participation rate: Not reported. No adjustment for age and gender. Blinding of examiners not mentioned in paper. Medical findings in neck and shoulder significant in data entry workers for head inclination greater than 56E vs. <56E. Not significant in conversational terminal workers or typewriters. Medical findings in neck and shoulder significant for typists with head rotation greater than 20E compared to <20E. The lower the table and keyboard heights, the more frequently pains in the shoulder, neck, and arms. No document holders used. Authors concluded the higher the table, the higher the documents, the better the posture of the head and trunk. Increased neck/shoulder findings occurred with increased turning of the head or head inclination. Job satisfaction, relationship with colleagues, superiors, decision making abilities, use of skills not significantly different among groups.

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Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Jonsson et al. 1988	Cohort	Electronics Workers (n=69 female) out of initial 96 workers.	Outcome: Three separate physical exams at yearly intervals (one initially) assessing tenderness on palpation, pain or restriction with active and passive movements; symptoms in previous 12 months with regard to character, frequency, duration, localization, and relation to work or other physical activities. Analyzed if score on any symptom of 2 or greater than on a 4 point scale; "severe" symptom score = 4. Carried out at outset of study: MVC of forearm flexors, shoulder strength, handgrip, heart rate using a bicycle ergometer and rating of perceived exertion. Exposure: Computerized via two video recordings (rear and side), real time; obtained frequency and duration of working postures and movements, neck flexion greater than 20E.	Severe neck disorders: After 1 year: 24% 22% at 2nd exam At 3rd exam, 38 subjects reallocated to varied tasks had improved (16% of these had severe symptoms) 26% with unchanged working conditions deteriorated further	Severe neck disorders: 11% initially	Predictors of change of health status from 2nd to 3rd examination: Palpation tenderness, neck/ shoulder angle: OR=1.6 Shoulder elevated, % of work-cycle: OR= 1.04 Satisfaction with work colleagues: OR=25 Satisfaction with work tasks: OR=24.5		Participation rate: 72%. Predictors of deterioration were previously physically heavy jobs, high productivity (after 1 year), and previous sick leave. Predictors of improvement were reallocation, physical activity in spare time, and high productivity (after 2 years). Predictors of remaining healthy were work without elevating the shoulders and satisfaction with work tasks. Subjects reallocated to new tasks characterized as more dynamic and varied: Non-sitting, no inspection of small details on printed circuit boards, standing and walking, occasionally sitting, caretaking work, surveillance of machinery, assembling of bigger and heavier equipment.

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Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Kilbom et al. 1986 Kilbom and Persson 1987	Cross-sectional	106 of 138 female assemblers in two electronic manufacturing companies agreed to participate; 10 excluded because of symptoms in past 12 months. 96 underwent medical, physiological, and ergonomic evaluation.	Outcome: Three separate physical exams at yearly intervals (one initially) assessing tenderness on palpation, pain or restriction with active and passive movements; symptoms in previous 12 months with regard to character, frequency, duration, localization, and relation to work or other physical activities. Analyzed if score on any symptom of 2 or >on a 4 point scale; "severe" symptom score = 4. Exposure: Carried out at outset of study: MVC of forearm flexors, shoulder strength, handgrip, heart rate using a bicycle ergometer and rating of perceived exertion. Included video analysis of postures and movements of the head, shoulder and upper arm including durations and frequencies. Recorded work cycle time and number of cycles/hr, time at rest for the arm, shoulder and head, rest periods, and average and total duration/work cycle and hr. The mean number of neck forward flexions >20E/hr was 728 (s.d. 365) in the initial 96 workers.	MSD symptoms in the neck/ shoulder using a 4 point severity scale: None: 78% Slight: 8% Moderate: 7% Severe: 3%	ð	Logistic Regression model (all variables significant at the *p*<0.05 level) Headache Average time/work cycle with upper arm 0-30E abducted Average time/work cycle in neck flexion Excessive general fatigue at end of working day		Participation rate: 77%. The authors followed up on the non-participants and found no significant differences from participants. No relation between maximal static strength and symptoms. Examiner blinded to case status. Questions included spare time physical activities, hobbies, perceived psychosocial stress at work, work satisfaction, number of breaks, rest pauses. Clinically diagnoses found were largely myofascial symptoms. Headache, sleep problems, dizziness showed a weak positive correlation. Age, years of employment, productivity, muscle strength were not related to symptoms. There was large inter-worker variation in working posture and working techniques. The more dynamic working technique, the less symptoms in the neck and neck/shoulder symptoms. Authors note: "a strong positive relationship to disorders was obtained with VIRA variables describing neck forward flexion and upper arm elevation." See Jonsson et al. 1988 for follow-up.

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Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Linton and Kamwendo 1989	Cross-sectional	420 of 438 medical secretaries and office personnel at a Swedish hospital. Those reporting frequently having neck and shoulder pain (1 to 3) compared to those less frequently having pain (4 to 6) points).	Outcome: 3-point scale collapsed from 6-point frequency scale ranging from "almost never" to "almost always" having neck or shoulder discomfort; and Nordic Musculoskeletal Pain Questionnaire. Exposure: 10-question standardized form on the psychological work environment with 1 to 4 categorical scales. Overall score and indexes on work content, psychologic work demand and social support at work. Duties included daily use of typewriter, VDT, plus mail telephone and appointment duties.	Shoulder pain frequency Very often: 16.9% Sometime wk: 3.8% Sometimes a wk: 4.8% Sometimes days: 13.8% Sometimes 1 day: 28.6% Never: 32.1%	ŏ	Those frequently having neck and shoulder pain vs. those less frequently having pain: Poor Work Content: OR= 2.5 Lack of Social Support: OR=1.6	 1.3-4.9 0.9-2.8	Participation rate: 96%. 75% sat >5 hr/day. 43% worked with office machines each day. Psychosocial scale scored: 10 to 20 as good environment. 20 to 40 as poor environment. Authors noted that: (1) Secretaries exposed to high work demands periodically, (2) they also felt helpless to change the work environment, and that (3) internal conflict within departments may have affected responses.

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Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Maeda 1982	Cross-sectional	119 accounting machine operators aged 17 to 29 years in a post-check office.	Outcome: Based on questionnaire responses of pain and stiffness in the right and left sides of the neck and shoulder based on frequency of "almost every day, occasionally, and never or seldom" during the previous several wk. Scores were factor analyzed. Exposure: Anthropometric parameters relevant to the job tasks were measured on 51 operators who showed large or small factor scores.		*p*<0.05	Partial correlation coefficient between head neck tilt and factor score 1 to 5, controlling for other angles "A and C", age, and length of service 0.25		Participation rate: Not reported. Examiners blinded to case status: Not reported. Constrained tilted head posture was associated with neck/shoulder stiffness.

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Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

				MSD prevalence				
Study	**Study design**	**Study population**	**Outcome and exposure**	**Exposed workers**	**Referent group**	**RR, OR, or PRR**	**95% CI**	**Comments**
Milerad and Ekenvall 1990	Cross-sectional	99 dentists randomly selected from Stockholm dentist registry who practiced $ 10 years compared to 100 pharmacists selected from all pharmacists in Stockholm.	Outcome: Based on telephone questionnaire: Neck symptoms at any time before the interview ("lifetime prevalence"). Further analyzed according to Nordic questionnaire as to duration during last 12 months and during last 7 days, effect on work performance, leisure activities, and sick leave. Exposure: Questionnaire included: (1) abduction of arm particularly in sit-down dentistry, (2) work hr/day, (3) static postures.	All dentists: Neck and Shoulder: 36%	17%	2.1	1.3-3.0	Participation rate: 99%. Analysis stratified by gender. No difference in leisure time, smoking, systemic disease, exposure to vibration. Symptoms increased with age in female dentists only. Duration of employment highly correlated with age (r=0.84, 0.89). No relation between symptoms and duration of employment. Equal problems dominant and non-dominant sides.
				Neck and Shoulder and Arm: 16%	3%	5.4	1.6-17.9	

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Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Ohara et al. 1976	Cross-sectional and pro-spective	For cross-sectional study: 399 cash register operators compared with 99 office machine operators and 410 other workers (clerks and saleswomen). All female. For prospective study: 56 workers employed <7 months had testing pre- and post-intervention using questionnaire and physical exam. 86 operators, newly hired after interventions, also had evaluation after 10 months of working.	Outcome: Assessed by standard health inventory and medical examination (used clinical classification according to the committee on cervicobrachial disorders of the Japan Association of Industrial Health, in Table 3 in the paper). Periodic physical exam performed twice a year from 1973. Primary exams performed on 371 operators. 130 (35%) received detailed exams. Exposure: To repetitive movements relocating merchandise across counter and bagging, involved muscle activity of the fingers, hands, and arms; extreme and sustained postures. Interventions: (1) a 2-operator system, 1 working the register, one packing articles, changing roles every hr; (2) continuous operating time <60 min; max. working hr/day 4.5 hr; (3) 15-min resting period every hr; (4) electronic cash registers with light touch keyboard substituted for half of previously used	Cash register operators Interventions did not result in reduced muscle fatigue of the neck, shoulders, and upper back brought on presumably by the continuous lifting of the upper limbs.	Office machine operators and other workers (clerks and saleswomen)	NR		Participation rate: for prospective study = 100%. Participation rate: for cross-sectional study, unable to calculate from data presented. Unknown whether examiners blinded to case status. Interventions did not reduce complaints in the shoulder region, but did improve symptoms in the arms, hands, fingers, low back, and legs. The lack of improvement in the shoulder region was stated to be due to the use of the same narrow check stands, unsuitable counter height, and necessity of continuous lifting of the upper limbs. Operators hired after the interventions and then examined after 10 months had less Grade I, II , or III occupational cervicobrachial disorders in examination than those hired before intervention. Only 14.5% with >3 years employment at worksite. Narrow work space and counter height not adjusted for height of worker. mechanical cash registers.

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Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Ohlsson et al. 1995	Cross-sectional	Industrial Workers (n=82 females) exposed to repetitive tasks with short cycles mostly far <30 sec., usually with a flexed neck and arms elevated and abducted intermittently; 68 former workers (mean employment time 21 years) who had left the factory during the 7 years before the study; these workers were compared to 64 referents with no repetitive exposure at their current jobs (female residents of a nearby town currently employed as customer service, ordering and price marking in supermarkets, as office workers (no constant computer work) or as kitchen workers.	Outcome: Pain in the last 7 days and PE diagnosing tension neck syndrome, cervical syndrome. Tension neck: Tightness of muscles, tender spots in the muscles. Cervical syndrome: Limited neck movement, radiating pain provoked by test movements, decreased sensibility in hands/fingers; muscle weakness of upper limb. Muscle strength measured by MVC at elevation, abduction, and outward rotation of both arms measured by dynamometer. Exposure: Videotaping and observation. Analysis of postures, flexion of neck (critical angles 15E and 30E). 74 workers videotaped $10 min. from back and sides. Average counts of two independent readers for frequencies, duration, and critical angles of movement used. Repetitive industrial work tasks divided into 3 groups: (1) Fairly mobile work; (2) Assembling or pressing items; and (3) sorting, polishing and packing items. Weekly working time, work rotation, patterns of breaks, individual performance rate (piece rate). Only exposure readings from right arm were used.	Industrial workers: 50%	Referents: 16%	All neck/shoulder clinical diagnoses (industrial workers compared to referents): OR=2.7 Logistic Model: Repetitive work vs. none: OR=4.6 Age (57 vs. 37): OR=1.9 Muscular tension tendency: (score 4.5 vs. 1) : OR=2.3 Stress/worry tendency: OR=1.9	1.2-6.3 1.9-12 1.0-3.5 1.3-4.9 1.1-3.5	Participation rate: Current workers: 96% Past workers: 86%; Referents: 100%. No exposure information available to examiners, "not possible to completely blind the examiners." Questionnaire included individual factors, work/environment, symptoms, psychosocial scales. Videotape analysis revealed considerable variation in posture even within groups performing similar assembling tasks. Logistic models replacing repetitive work with videotape variables found muscular tension tendency and neck flexion movements significantly associated with neck/shoulder diagnoses. Inverse relationship between duration of industrial work and MSDs, largest OR in those employed <10 years. Assembly group had high OR (6.7) with regard to neck/shoulder MSD compared to referents. Significant association between time spent in neck flexion positions <60E.

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Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Punnett et al. 1991	Cross-sectional	254 of 275 (92%) meatcutters and wrappers who attended health and safety training classes. Workers fulfilling outcome case definition (cases) were compared to non-cases; also compared to the U.S. industrial population.	Outcome: Based on self-reported symptom survey. Cases were defined if they met the following: $ 20 episodes in the previous year or usual duration of $ one wk; reported date of pain onset after employment in the retail meat industry; no history of systemic disease related to soft tissue pain; and, no history of acute injury. Exposure: Based on interview and authors observations. Exposure: Repetitive and strenuous activities (it was not stated whether this was for specific area or involved neck and all upper extremity areas) for 0.5 to 8 hr/day in refrigerated areas. Cutters cut an average 121 (+ 278) large pieces of meat/day filled 701 (+ 830 boats). Wrappers filled 374 (+ 602 boats/day). Wrapped 1,299 (+ 1,365 boats and weighed 1,399 boats).	Overall Prevalence Neck/Shoulder: 53%	õ	Male: 1.8 Female: 0.9	1.0-3.2 0.5-1.9	Participation rate: 92%. Stratified by gender and age. Neck/shoulder disorders associated with external duration of static postures (>5 sec.) or lifting $ 5 lbs. while abducting, flexing or extending the shoulder. Neck/shoulder pain did not vary by job category. 98% of respondents performed lifting tasks at work. "They judged lifting an average load/day was 41 (+ 23) lb lifted 33 times and carried 9 feet. Heaviest load = 71 (+ 31 lb), lifted 11 times and carried 9 feet/lift." Listing an average load with a 40 to 50% standard deviation can be misleading. Neck/shoulder cases lifted both the "typical" and "heaviest" loads with greater frequency than non-cases. Association was found for extended duration of and lifting weight in abduction/flexion and extension of the shoulder.

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Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Rossignol et al. 1987	Cross-sectional	191 Computer and data processing services, public utilities of Massachusetts State Department, at 38 work sites selected at random from Massachusetts employers of >50 workers. 28 of the 191 did not use a computer.	Outcome: Self-administered questionnaire case defined as: Neck pain, stiffness, or soreness occurring almost always or missed work due to neck pain, stiffness or soreness. Exposure: Self-reports of number of hr worked each day with a keyboard machine with a VDT. Subjects selected after observation of worksite.	½ to 3 hr of VDT use/day (n=31): 39% 4 to 6 hr of VDT use/day (n=28): 57% 7 or more hr of VDT use/day (n=104): 61%	No VDT use (n=28): 25%	Up to 3 hr of VDT use compared to 0 hr of use: OR=1.8 4 to 6 hr of VDT use compared to 0 hr of use: OR=4.0 >7 hr of VDT use compared to 0 hr of use: OR=4.6	0.5-6.8 1.1-14.8 1.7-13.2	Participation rate: In 6 industry groups 67 to 100%. Participation rate: For individual clerical workers; 94 to 99%. Assessed magnitude of confounding by age, cigarette smoking, industry, educational VDT training. Study presented to participants as a "general health" survey (as opposed to an occupationally related survey) to avoid observation bias.

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Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Ryan and Bampton 1988	Cross-sectional	143 data process operators; using a 0 to 10 point scale, the group with symptom scores of 8 or above (n=41) were designated "cases," and were compared to group with symptom scores of 2 or less (n=28).	Outcome: Based on symptoms occurring three or more times/wk with no physical exam signs, or $ weekly symptoms with physical exam signs of muscle tenderness or hardening present. Cases were selected by having a combination of symptoms in the lower arm and shoulder/neck area meeting a summary score of eight or more. These cases were compared to a comparison group with a score of 2 or less. Exposure: Ergonomic assessment measuring angles and distances of each operator seated at his/her workstation performed; Questionnaire responses to: Time spent in current job, time spent altogether keying or typing work, training in the adjustment of their chair, desk, or keyboard.	Shoulder: 44% symptom only Neck: 43% symptoms only Neck/shoulder symptoms occurring $ 3 times weekly with no signs or weekly with signs: 44%	Comparison group had symptom scores <2.	More non-cases trained in adjustment of chairs Cases with higher scores of visual discomfort Cases felt there was not enough time for rest breaks compared to non-cases Cases had more boredom, more work stress, and needed to push themselves >3 times/wk; lower peer cohesion, autonomy, clarity in the authority structure. Higher staff support and work pressure.	*p*<0.05 *p*<0.05 *p*<0.05 *p*<0.05	Participation rate: 99%. Interviewers blinded to questionnaire responses. Height, weight, sex, age, marital status, parental status evaluated and not found to be confounders. Handedness, time spent in current job, time spent altogether keying or typing work, training in adjustment of keyboard and desk evaluated in two groups and no significant differences found. Psychosocial and work environment scales included pertaining to job satisfaction as well as the Work Environment Scale [R. Moos 1974]. Authors diagnosed “myalgia” as diffuse muscle pain and tenderness.

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Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Tola et al. 1988	Cross-sectional	828 Machine operators; 658 carpenters; compared to 657 office workers; All male, ages 25 to 49 years.	Outcome: Postal questionnaire on neck or shoulder symptoms frequency in last year, and influence on work methods, daily duties and activities or leisure time hobbies. Pain Drawing Diagram used to distinguish body areas. For logistic regression model 12 month prevalence of neck and shoulder symptoms on 8 days or more. Exposure: Exposure based on occupation: Machine operators known to be exposed to static loading due to prolonged sitting and low-frequency whole body vibration, fast work pace, and upper trunk twisting. Carpenters exposed to dynamic physical work with varying postures and loads, static loading of neck/shoulder-arm, and male office workers, of whom only 40% were performing routine office tasks.	Daily symptoms: machine operators: 11% carpenters: 8% Change work methods: machine operators: 19% carpenters: 21%	Daily symptoms: office workers: 2% Change work methods: office workers: 10%	Machine vs. office: OR=1.7 Carpenter vs. office: OR=1.4 Machine vs. carpenter: OR=1.3 Use of twisted or bent postures during work Little: OR=1.0 Moderate: OR=1.2 Rather much: OR=1.6 Very much: OR=1.8 Working in a draft: No: OR=1.0 Yes: OR=1.1 Job satisfaction Very good: OR=1.0 Rather good: OR=1.1 Moderate or poor: OR=1.2 Age (years) 25 to 29: OR=1.0 30 to 34: OR=1.2 35 to 39: OR=1.3 40 to 44: OR=1.5 45 to 49: OR=1.6	1.5-2.0 1.1-1.6 1.1-1.4 1.0-1.5 1.4-1.9 1.5-2.2 1.0-1.3 1.0-1.3 1.1-1.4 1.0-1.5 1.1-1.6 1.3-1.8 1.4-1.9	Participation rate: 74% machine operators, 67% carpenters, 67% office workers. Adjusted for years in occupation, age. Interaction terms tested for, none found. Education, general health, and leisure time activities, car driving included in analysis. Study restricted to males aged 25 to 49 years. Education status (“$ some vocational school” compared to “no > some courses”) statistically significant for machine operators’ and carpenters’ reporting of symptoms.

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Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Vihma et al. 1982	Cross-sectional	40 Sewing machine operators with short work cycles compared to 20 seamstresses.	Outcome: Neck or shoulder complaints defined by questionnaire: Recurrent pain or aching in present work (during or after work). Exposure: Observation and interview; hr continuously sitting, standing time, survey of work postures, length of work cycle. Sewing machine operator cycle time was 30 to 60 sec. in duration. Seamstresses had longer cycle.	Sewing machine operators with neck/shoulder complaints: 98%	Seam-stresses with neck/shoulder complaints: 60%	PRR = 1.6	1.1-2.3	Participation rate: Not reported. Random selection of participants. Cases and referent group matched for age and duration of employment. Sewing machine operators found to have significantly greater static work compared to seamstresses.

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Table 2–8 (Continued). Epidemiologic studies evaluating work-related neck/shoulder disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Viikari-Juntura et al. 1991a	Cohort	154 subjects (72 female, 82 male) from Helsinki, Finland. Subjects were part of a longitudinal study population that started in Finland in 1955; and from 1961 to 1963. During that time, 1084 subjects underwent cross-sectional examination. In 1985, a questionnaire was sent to all subjects; 801 (74%) responded. Of the respondents, 180 lived in the Helsinki area. It was from this group that 162 responded. Eight were excluded due to illnesses. The proportions of the highest income levels in the sample exceeded the Finnish population.	Outcome: Based on Questionnaire data: Ache, pain, stiffness, numbness in their neck/shoulder in last 12 months. Visual analogue scale of intensity, disability. Severe neck disability: Pain for >7 days in last 12 months and mean disability index $ 15. Physical exam (P.E.): Two tests for cervical nerve root involvement, neck compression test, shoulder abduction test. Because of small number of abnormal physical findings, the P.E. was eliminated from analysis Exposure: Questionnaire: Amount of work with hands overhead, work in forward bent position, work in twisted or bent position.	10% of female and 2% of male reported severe radicular neck pain 21% of female and 2% of male reported any type of severe neck/shoulder pain	ð	Female: Severe neck/shoulder symptoms vs. no symptoms Alexithymia (low verbal productivity) (continuous): OR=1.02 Social confidence (moderate fears vs. no fears): OR=0.04 (much fear vs. no fears): OR=1.4 Type of income (monthly salary): OR=0.5 Sense of coherence (continuous): OR=0.95 Twisted or bent torso (>3 hr/day vs. <1 hr/day: OR= 0.9 >3 hr/day vs.<1 hr/day Sitting in a forward posture 1-3 hr/day vs. <1hr/day: OR=10.7 >3 hr/day vs. <1 hr/day: OR=1.5	0.97-1.1 0.0-4.5 0.05-42.2 0.05-5.2 0.9-0.99 0.8-10.0 .4-291 0.07,29.6	Participation rate: 90%. Controlled for physical and creative hobbies, no interactions seen. Because of low numbers, males were not included in analysis. Subjects comprised of mostly high socioeconomic status who reported light physical workloads. Data collection in 1955 to 1963: Intelligence, alexithymia, social confidence, hobbies, motor development, verbal development, level of education of parents, type of income of family. Data collection in 1985: Questionnaire on family relationships, socioeconomic status, work history, characteristics of present work, job satisfaction, mental resources. Data collection in 1986 to 1987: Questionnaire: Physical characteristics of work, amount of physical exercise, illnesses, trauma. Measurements taken in adolescence, such as intelligence, alexithymia, social confidence, hobbies and socioeconomic status of the family showed no consistent association with neck/shoulder symptoms in adulthood.

CHAPTER 3
Shoulder Musculoskeletal Disorders: Evidence for Work-Relatedness

SUMMARY

There are over 20 epidemiologic studies that have examined workplace factors and their relationship to shoulder musculoskeletal disorders (MSDs). These studies generally compared workers in jobs with higher levels of exposure to workers with lower levels of exposure, following observation or measurement of job characteristics. Using epidemiologic criteria to examine these studies, and taking into account issues of confounding, bias, and strengths and limitations of the studies, we conclude the following:

There is **evidence** for a positive association between highly repetitive work and shoulder MSDs. The evidence has important limitations. Only three studies specifically address the health outcome of shoulder tendinitis and these studies involve combined exposure to repetition with awkward shoulder postures or static shoulder loads. The other six studies with significant positive associations dealt primarily with symptoms. There is **insufficient evidence** for a positive association between force and shoulder MSDs based on currently available epidemiologic studies. There is **evidence** for a relationship between repeated or sustained shoulder postures with greater than 60 degrees of flexion or abduction and shoulder MSDs. There is evidence for both shoulder tendinitis and nonspecific shoulder pain. The evidence for specific shoulder postures is strongest where there is combined exposure to several physical factors like holding a tool while working overhead. The association was positive and consistent in the six studies that used diagnosed cases of shoulder tendinitis, or a constellation of symptoms and physical findings consistent with tendinitis, as the health outcome. Only one [Schibye et al. 1995] of the thirteen studies failed to find a positive association with exposure and symptoms or a specific shoulder disorder. This is consistent with the evidence that is found in the biomechanical, physiological, and psychosocial literature.

There is **insufficient evidence** for a positive association between vibration and shoulder MSDs based on currently available epidemiologic studies.

INTRODUCTION

Shoulder MSDs and their relationship to work risk factors have been reviewed by several authors [Hagberg and Wegman 1987; Kuorinka and Forcier 1995; Sommerich et al. 1993; Winkel and Westgaard 1992]. Hagberg and Wegman [1987] attributed a majority of shoulder problems occurring in a variety of occupations to workplace exposure. Kuorinka and Forcier [1995] looked specifically at shoulder tendinitis and stated that the epidemiologic literature is “most convincing” regarding work-relatedness, especially showing an increased risk for overhead and repetitive work.

The focus of this review is to assess evidence for a relationship between shoulder tendinitis and workplace exposures to the following: awkward postures, forceful exertions, repetitive exertions, and segmental vibration. Also included are studies relevant to shoulder disorders—as defined by a combination of symptoms and physical examination findings or by symptoms alone, but not specifically defined as tendinitis—and those studies for which the health outcome combined neck and shoulder disorders, but where the exposure was likely to have been specific to the shoulder. Chapter 2 discusses studies involving neck-shoulder disorders where assessment of exposure was likely specific to the neck region.

Pertinent information about the 39 reviewed studies is presented in several ways. Detailed descriptions of the studies are provided in Table 3-5. The text of this section on shoulders is organized by exposure risk factor. The discussion within each risk factor is organized according to criteria presented on Pages 1-1 to 1-10 of the Introduction. Conclusions are presented with respect to the specific MSD of concern, shoulder tendinitis.

REPETITION

Definition of Repetition for Shoulder MSDs

Studies that addressed the physical factor of repetition and its relation to shoulder MSDs were included in this review. Studies usually defined repetition, or repetitive work, for the shoulder as work activities that involved cyclical flexion, extension, abduction, or rotation of the shoulder joint. Repetitiveness was defined in four different ways in the reviewed studies: (1) the observed frequency of movements past pre-defined angles of shoulder flexion or abduction, (2) the number of pieces handled per time unit, (3) short cycle time/repeated tasks within cycle, and (4) a descriptive characterization of repetitive work or repetitive arm movements. Some of the studies that examined repetition as a risk factor for shoulder MSDs had several concurrent or interacting physical work load factors. Therefore, repetitive work should not be considered the primary exposure factor, particularly independent of posture. Some studies indirectly inferred shoulder repetition by characterizing hand, wrist, and forearm movements.

Studies Reporting on the Association of Repetition and Shoulder MSDs

Three of the reviewed studies reported results on the association between repetition and shoulder tendinitis [English et al. 1995; Ohlsson et al. 1994, 1995]. For all three studies, some or all of the results were for associations with a combined exposure to repetition and awkward posture. Six additional studies reported results on the association between repetition and non-specific shoulder disorders [Sakakibara et al. 1995], non-specific shoulder symptoms [Andersen and Gaardboe 1993a; Ohlsson et al. 1989], combined neck-shoulder disorders [Bjelle et al. 1981; Chiang et al. 1993] or combined neck-shoulder symptoms [Kilbom et al. 1986; Kilbom and Persson 1987].

Studies Meeting the Four Evaluation Criteria

Four studies met all four of the criteria [Chiang et al. 1993; Kilbom et al. 1986; Ohlsson et al. 1994, 1995] (Table 3-1, Figure 3-1). Chiang et al. [1993] studied workers in the fish processing industry in Taiwan. The health outcome of “shoulder girdle pain” was defined as self-assessed symptoms of pain in the neck, shoulder or upper arms, and signs of muscle tender points or palpable hardenings upon physical examination. Pain referred from a nerve root or other spinal source was included in the case definition. The force requirements of the jobs were estimated by surface electromyographs (EMGs) in the forearm flexor muscles. This is not a direct measure of shoulder muscle activity. There may be no relationship between the level of activity in the forearm and shoulder girdle muscles. Three categories, based on both force and repetitiveness, were used as the exposure outcome: Group I (low force, low repetitiveness), Group II (high force or high repetitiveness), and Group III (high force and high repetitiveness). Force was also evaluated independently in multivariate analyses.

Kilbom et al. [1986] performed a prospective study in which female employees in the electronics manufacturing industry were observed for a 2-year period. The health outcome in the neck, shoulder, or arm regions was based on symptoms and physical findings. Symptom severity was coded on the basis of its character, frequency, and/or duration. Changes in severity status at follow-up evaluations were used as the dependent variables in multiple regression analyses. Neck, shoulder, and upper arm posture was determined by VIRA. Although the health outcome combined symptoms from different body regions, knowledge of biomechanical theory can be used to identify significant predictors related to the shoulder symptom severity.

For the two Ohlsson et al. [1994, 1995] studies, the authors reported that the examiners could not be completely blinded to exposed versus referent status, but that a standard protocol was followed and observer bias was likely to have been minimal. As examiners were blinded to objective exposure measures, analyses testing associations between neck-shoulder disorders and specific postures would not have been biased [Ohlsson et al. 1995].

In the first of the Ohlsson et al. studies, a cross-sectional study, women in the fish industry were compared to a control population of women employed in municipal workplaces in the same towns [Ohlsson et al. 1994]. Diagnoses of shoulder disorders (e.g., tendinitis, acromioclavicular syndrome, frozen shoulder) were made on the basis of symptoms determined by interview and a physical exam. Exposure evaluation of each work task held by the fish industry population was evaluated with ergonomic workplace analysis (EWA). Ten different factors were rated on a scale from 1 to 5 and the combined ratings were used as a profile of the work task. Based on this profile, the authors reported that fish industry work was found to be “highly repetitive” and to include “poor work postures.”

Ohlsson et al. [1995] compared a group of women who performed industrial assembly work to a referent group of women from a nearby town who were employed in jobs characterized as having varied and mobile work tasks. One examiner assessed signs and symptoms. The examiner was blinded to specific exposure information, but not completely blinded to factory worker versus referent group status. Shoulder tendinitis included supraspinatus, infraspinatus, and bicipital tendinitis. Another health outcome combined neck and shoulder disorders (tension neck, cervical syndrome, thoracic outlet syndrome, frozen shoulder, tendinitis, acromioclavicular syndrome). In a descriptive assessment, it was reported that the work tasks in the study group involved repetitive arm movements with static muscular work of the neck and shoulder muscles. The percentage of time spent in specific upper arm postures was determined from videotaped observation of 74 (out of 82) workers. The average result from two independent videotape analyses was used. Posture category demarcations included 0, 30, and 60 degrees for arm elevation, and 30, 60, and 90 degrees for arm abduction.

Studies Not Meeting the Four Evaluation Criteria

Bjelle et al. [1981] compared cases with acute, non-traumatic shoulder-neck pain to age- and sex-matched, paired controls. To determine exposure, each case and control was filmed and a biomechanical analysis was performed to determine the frequency and duration of shoulder abduction or forward flexion > than 60 degrees.

In the study by English et al. [1995], cases were determined by medical diagnosis and controls were selected from patients evaluated at specified orthopedic clinics. For statistical analyses, all diagnoses were grouped by anatomical site. The diagnoses for shoulder cases were rotator cuff injury, rupture of long head of biceps, shoulder capsulitis, and symptomatic acromioclavicular arthritis. It is assumed that shoulder tendinitis is included in this group. Exposure measures were determined by a standardized interview conducted by an interviewer who was "unaware of the case-control status of the individual wherever this was possible."

In a study by Sakakibara et al. [1995], the health status of a group of women farm workers was assessed during the performance of two different tasks, with a 1-month interval between the tasks. The health outcome was defined by self-assessed symptoms of shoulder stiffness and pain and a physical examination for muscle tenderness and joint pain on movement. Whether the examining physician was aware of the prior hypothesis regarding differing exposures between the two tasks (bagging pears versus bagging apples) was not stated. Exposure was based on self-report of the number of hours per day spent bagging, the number of pears or apples bagged per day, and the total number of days spent bagging each fruit. One worker was observed for 3 hours while performing each bagging job, with repeated goniometric measures of shoulder forward flexion angles done each minute. While there was no difference in the total number of days or number of hours per day spent bagging each fruit, significantly more pears than apples were bagged per day. The proportion of time spent with the angle of shoulder forward flexion greater than 90 degrees was significantly larger when bagging pears (75%) than when bagging apples (41%).

One study did not meet any of the criteria. In a cross-sectional study by Ohlsson et al. [1989], the exposed population was factory employees who produced and assembled plastic components. Work exposure was characterized as "repetitive arm and hand movements in constrained work postures." The referent population was composed of women randomly sampled from the general population in a nearby area. The health outcome was determined by self-reported symptoms of shoulder pain during the previous seven days. The exposure measure was the self-reported number of items completed per hour. The range was from less than 100 items completed per hour (slow category) to more than 700 items per hour (very fast category). Self-reporting was believed to be accurate because workers were paid by the piece.

Strength of Association: Repetition and Shoulder MSDs

Using the data presented in the study by Ohlsson et al. [1994], for supraspinatus, infraspinatus, or bicipital tendinitis the odds ratio (OR) for working in the fish industry (repetitive work, poor posture) was calculated as 3.03 (95% CI 2.5–7.2). For shoulder tendinitis alone, the PRR was calculated as 3.5 (95% CI 2.0–5.9). For clinical diagnoses of the neck and shoulder, the OR for working in the fish industry versus the referent population was 3.2 (95% CI 2.0–5.3).

Using data presented in the study by Ohlsson et al. [1995] for supraspinatus, infraspinatus, or bicipital tendinitis, the OR for being an assembly worker (repetitive arm movements with static load on shoulders) versus the referent population was 4.2 (95% CI 1.35–13.2). For neck-shoulder disorders, the OR for being an assembly worker versus the referent group was 5.0 (95% CI 2.2–11.0).

Using multiple logistic regression analysis with age, gender, and force as covariates, Chiang et al. [1993] found that highly repetitive upper extremity movements were associated with shoulder girdle pain (OR 1.6, 95% CI 1.1–2.5). When tested in the same model with force and repetition, the interaction term for force and repetition was also significant (OR 1.4, 95% CI 1.0–2.0). Several factors could have resulted in an underestimation of the strength of association: no requirement that symptoms had begun on current job means that some symptomatic workers may have transferred to lower risk jobs. Relative to shoulder MSDs, the major limitation of this study was that the exposure assessment was not specific to movement at the shoulder joint and may therefore have either over- or underestimated repetition at the shoulder. In some cases the exposure assessment may have been a measure of repetitive upper arm movements, but it may also have been a measure of repetitive hand and distal upper extremity activity occurring in the context of a static load on the shoulder muscles.

For the shoulder diagnoses used to form their group of cases, English et al. [1995] found an association with repeated shoulder rotation with an elevated arm (OR 2.30, $p < 0.05$). They also found what appeared to be a protective effect associated with elbow flexion (OR 0.4, 95% CI 0.2–0.8). This effect was greatest at low amounts of daily cumulative exposure to elbow flexion; the protective effect decreased (RR increased) as the number of hours of total daily elbow flexion increased. In a laboratory study of shoulder muscle activity in relation to different combinations of shoulder and elbow joint postures (a total of 21 different postures), Herberts et al. [1984] found that humeral rotation and elbow flexion had insignificant effects on shoulder muscle activity. However, the postures tested by that study were stationary, whereas the associations reported by English et al. [1995] appear to be related to repetitive movements.

For symptoms of shoulder pain within the previous 7 days, the OR for assembly workers versus the referent group was 3.4 (95% CI 1.6–7.1) [Ohlsson et al. 1989]. A significantly higher proportion of the farm workers studied by Sakakibara et al. [1995]

had signs of shoulder muscle tenderness while bagging pears than while bagging apples. There was no way to analyze the relative contribution to risk of repetitive shoulder exertions (increased number of pears picked per day) and awkward posture (greater portion of each day spent with extreme forward flexion when picking pears).

Consistency of Association

Repetitiveness was defined in four different ways in the reviewed studies: (1) the observed frequency of movements past pre-defined angles of shoulder flexion or abduction, (2) the number of pieces handled per time unit, (3) short cycle time/repeated tasks within cycle, and (4) a descriptive characterization of repetitive work or repetitive arm movements.

Repetition Characterized as Frequency of Movements Past Pre-Defined Shoulder Angles

Bjelle et al. [1981] and Ohlsson et al. [1995] found a significant positive association between the prevalence of neck-shoulder disorders and the frequency of upper arm movements past 60 degrees of flexion or abduction. English et al. [1995] found a significant association between diagnosed cases of shoulder disorders and repeated shoulder rotation with an elevated arm posture.

Repetition Characterized as the Number of Pieces Handled per Time Unit

A significant positive association was found between both nonspecific shoulder symptoms [Ohlsson et al. 1989] and nonspecific shoulder disorders [Sakakibara et al. 1995] and the number of pieces handled per hour or per day.

Repetition Characterized as Short Cycle Time

Chiang et al. [1993] found a significant association between a very short or repetitive cycle (<30 seconds or >50% spent repeating same task) and shoulder girdle pain.

Repetition Characterized Descriptively

Three studies by Ohlsson et al. found a significantly higher proportion of shoulder MSDs in exposed populations with work characterized as involving repetitive arm and hand movements than in referent populations [Ohlsson et al. 1989, 1994, 1995].

Repetition Combined with Static Shoulder Load

Except for the study by Sakakibara et al. [1995], in which the increased number of pears bagged per day was associated with an increased proportion of the work day spent with extreme shoulder flexion, the studies using measures of piece work or repetitive arm movements as the exposure outcome did not specify which joints or body regions participated in the repetitive action. Ohlsson et al. [1995] described the assembly work performed by the exposed population as combining repetitive arm movements with a static shoulder load. It is possible that the association between piece work, short cycles, or repetitive hand-arm movements and shoulder disorders reported by the other authors is related to a sustained, static load on the shoulder muscles as the upper arm is stabilized in a posture of mild to severe flexion or abduction, while repetitive movements are performed by the hand-wrist-forearm.

Temporal Relationship

In the prospective study by Kilbom et al. 1986; Kilbom and Persson 1987; and Jonsson et al. 1988 the number of shoulder elevations per hour was a strong predictor for a change to severe status at the 1- and 2-year follow-up evaluations. Although the change in status included problems in the neck and arm, as well as the shoulder, it is reasonable to assume that repetitive shoulder elevations would have had the greatest effect on disorders of the shoulder.

Several studies with a cross-sectional design used techniques to determine whether the health outcome of interest had occurred since, or was present during, exposure to hypothesized risk factor(s) of interest. Case definitions which required a positive physical examination finding [Chiang et al. 1993; Ohlsson et al. 1994, 1995] or where symptoms had occurred within the recent past [Chiang et al. 1993; Ohlsson et al. 1989, 1994] were designed to focus on disorders most likely to have been caused or aggravated by current work exposures.

Exposure-Response Relationship

Chiang et al. [1993] found a significant increasing trend in the prevalence of shoulder girdle pain from Group I (low force, low repetitiveness) to Group III (high force, high repetitiveness). However, the health outcome was not specific to shoulder disorders, and the exposure categories combine increasing repetitiveness—as defined by either less than a 30-second cycle time or a repeated task within the job cycle—and increasing forearm flexor muscle activity. Ohlsson et al. [1995] found that neck and shoulder disorders among assembly workers were significantly associated ($p<0.05$) with both the number of arm elevation movements from less than to greater than 60 degrees and the number of arm abduction movements from less than to greater than 60 degrees. Bjelle et al. [1981] found that the frequency of shoulder abduction or forward flexion (past 60 degrees) was significantly greater ($p<0.005$) for cases with neck-shoulder disorders than for controls.

In the study of assembly workers by Ohlsson et al. [1989], the number of pieces completed per hour was categorized as follows: slow: <100, medium: 100–299, fast: 300–699, very fast: >700. In this study, the ORs are shown in a figure, rather than reported in the text. Compared with the slow-paced group, the odds for symptoms of shoulder pain is approximately seven times that for those workers in the medium-paced group and approximately nine times that for those in the fast-June 26, 1997 pace group. While adjusting for age and length of employment, the OR for shoulder pain was significantly higher for the medium- and fast-paced groups than for the slow-paced group ($p=0.0006$). The OR for the very fast-paced group compared to the slow-paced group was between 1.0 and 2.0 and was not significantly different from the slow-paced group. The authors hypothesized that symptomatic workers may have self-selected out of the very fast paced jobs or that other unknown factors may have mitigated the effects of work pace.

When comparing fish industry workers to the reference population, Ohlsson et al. [1994] found that among those workers younger than age 45, the ORs for disorders of the neck and shoulders were significantly elevated and increased with duration of employment [0–5 years, OR 3.2 (95% CI 1.5–7.0); >5 years, OR 10 (95% CI 4.5–24)]. In their study of assembly workers, Ohlsson et al. [1989] found a statistically significant increase in the odds for pain in the shoulder with duration of employment (p=0.03) which was dependent on age. The increase with duration of employment had a steeper slope for younger (<35 years) assembly workers than for the older subgroup (i.e., among those workers employed for short durations, older women had more symptoms, and among those workers employed for long durations, younger women had more symptoms). This was thought to be a reflection of both survivor bias as well as the possibility that older new hires may have experienced a relatively more rapid onset of symptomatic problems than do younger women.

Coherence of Evidence

Repetitive movements of the upper extremity involving flexion or abduction of the glenohumeral joint would increase the frequency of effects such as fatigue and tendon circulation disruption hypothesized to occur as a result of such postures. These effects could be magnified by the addition of a hand-held load. Repetition may also be solely related to the development of tendinitis. In a laboratory study, Hagberg [1981] induced acute shoulder tendinitis in female subjects performing repetitive shoulder elevations for one hour. Six female students, ages 18–29, all developed shoulder tenderness (two with tendinitis) when exposed to 15 shoulder flexions (from 0 to 90 degrees) per minute for 60 minutes while holding up to 3.1 kg (6.4 lb) of weight.

Some of the significant associations reported may have been related to exposure to repetitive work in the distal upper extremity while the shoulder and upper arm were maintained in a static posture [Chiang et al. 1993; Ohlsson et al. 1989, 1994, 1995]. Winkel and Westgaard [1992] have pointed out that, “It is not possible to use the arm/hand without stabilizing the rotator cuff girdle and the glenohumeral joint. Therefore, work tasks with a demand of continuous arm movements generate load patterns with a static load component.”

The finding that the supra- and infraspinatus muscles were particularly prone to fatigue when subjects performed overhead work led Herberts et al. [1984] to hypothesize that the rotator cuff muscles may develop high intramuscular pressures at relatively low contraction levels. These high intramuscular pressures could lead to an impairment of intramuscular circulation, which could contribute to the early onset of fatigue. Intramuscular pressure increases with the muscle contraction level, and impaired circulation has been demonstrated at levels of contraction as low as 10–20 percent of maximal voluntary contraction (MVC). [Hagberg 1984].

The increased pressure in rotator cuff muscles and increased pressure on the supraspinatus tendon may trigger two different events that are both related to impaired microcirculation. The impaired microcirculation in the tendon may also result from tension within the tendon produced by forceful muscle contractions [Rathburn and Macnab 1970]. An inflammatory infiltrate with increased vascularity and edema within the rotator cuff tendons, especially the supraspinatus tendon may be a result of or a contributor to the process. If the inflammation process is sufficiently intense, then shoulder tendinitis may occur. If the process is less intense, and more chronic, then it may contribute to a degenerative process in the tendons of the rotator cuff. In the muscles of the rotator cuff, the impaired microcirculation may lead to small areas of cell death. A reasonable hypothesis is that repeated or sustained episodes of muscle ischemia result in localized cell death and persistent inflammation.

Neither of these proposed models for shoulder muscle pain or tendinitis suggest that all muscle activity is potentially harmful. Both muscles and tendons are strengthened by repeated activity if there is sufficient recovery time. However, the models present plausible mechanisms by which work tasks with substantial shoulder abduction could contribute both to shoulder pain and tendinitis.

There is evidence of a relationship between shoulder tendinitis and highly repetitive work. However, there are several limitations to the evidence. In the three studies for which the health outcome was shoulder tendinitis, the exposure combined repetition with awkward shoulder posture and/or a static shoulder load [English et al. 1995; Ohlsson et al. 1994, 1995]. Five out of the eight studies reviewed used either nonspecific shoulder disorders, nonspecific shoulder symptoms or combined neck-shoulder disorders as the health outcome.

Despite the limitations of the evidence, significant and positive relationships between repetitiveness, regardless of the measurement method, and shoulder MSDs or symptoms were found in all studies. Of the eight studies in which the effect of repetition was examined, three studies found ORs above 3.0 [Ohlsson et al. 1989, 1994, 1995] and three studies found ORs from 1.0 to 3.0 [Chiang et al. 1993; English et al. 1995; Sakakibara et al. 1995]. The remaining studies were prospective studies [Jonsson et al. 1988; Kilbom and Persson 1987] or studies that reported risk indicators other than OR [Bjelle et al. 1981].

In none of these studies is it likely that age, the most important personal characteristic associated with shoulder tendinitis and other shoulder disorders, or nonoccupational factors such as sports activities, caring for young children, or hobbies explained these associations. There is evidence of a relationship between shoulder tendinitis and highly repetitive work.

FORCE

Definition of Force for Shoulder MSDs

Studies that examined force or forceful work or heavy loads to the shoulder, or described exposure as strenuous work involving the shoulder abduction, flexion, extension, or rotation that could generate loads to the shoulder region were also included. Most of the studies that examined force or forceful work as a risk factor for shoulder symptoms or tendinitis had several concurrent or interacting physical work load factors. However, there is still a need to summarize present knowledge about the relationships between forceful work and shoulder MSDs. This section summarizes that knowledge, while acknowledging that other factors can modify the response.

Neck-shoulder disorders are discussed in Chapter 2.

Studies Reporting on the Association of Force and Shoulder Tendinitis

There are five studies which reported results on the association between force and adverse shoulder health outcomes (Table 3–2, Figure 3–2). The epidemiologic studies that addressed forceful work and shoulder MSDs tended to compare working groups by classifying them into broad categories based on an estimated amount of resistance or force of exertion and a combination of estimated rate of repetition [Andersen and Gaardboe 1993a; Chiang et al. 1993] or in terms of overall load [Herberts et al. 1984; Stenlund et al. 1992; Wells et al. 1983].

Studies Meeting the Four Evaluation Criteria

Chiang et al. [1993] studied workers in the fish processing industry. (This study was described in detail in the section on shoulder MSDs and repetition.) Chiang et al. [1993] did not report an exposure specific to the shoulder.

Studies Not Meeting the Four Evaluation Criteria

Andersen and Gaardboe [1993a] performed a cross-sectional study in which a cohort of sewing machine operators was compared to a random sample of women in the general population of the same region. Chronic shoulder pain was defined as a having experienced a continuous pain episode lasting more than 1 month and either daily pain or pain lasting more than 30 days in the same location within the previous year (per self-administered questionnaire). In order to compare the current exposure of sewing machine operators and those in the control group, the authors' experience and knowledge of the jobs were used to assign job titles to exposure categories based on crude assessments of force and repetitiveness. High exposure was characterized as a combination of high repetitiveness (activity repeated several times per minute) and low or high force, or medium repetitiveness (activity repeated many times per hour) and high force. Medium exposure was characterized as medium repetitiveness and low force, or low repetitiveness (jobs with more variation) and high force. Those in teaching, academic, self-employed, or nursing professions were classified as low exposure. The exposure classification scheme in this study does not allow separation of the effects of force from those of repetition. More sewing machine operators than referents were considered to have high exposure (41% versus 15%), but more in the referent population were considered to be in the medium exposure group (44% versus 22%). Because the outcome of interest was duration of historical exposure, current exposure was included as an independent variable in multivariate regression analyses.

Herberts et al. [1984] added to the 1981 study by comparing the prevalence of supraspinatus tendinitis between plate-workers and office clerks. Tendinitis in welders was determined by a combination of self-reported symptoms and positive physical examination findings. The only information given regarding plate-work is that it is dynamic in character. It is presumed that plate-workers handled heavy loads more frequently than office clerks.

In a cross-sectional study, the prevalence of osteoarthrosis in the acromioclavicular joint, as determined by radiography, was compared among three groups of workers in the construction industry [Stenlund et al. 1992]. The three groups were bricklayers, rock blasters, and construction foremen. The foremen did not perform manual work currently, or in the past, and were considered the control population. A standardized interview was used to determine exposure factors, including job title and the sum of loads lifted during all working years (expressed in tonnes). Analyses were performed separately for right and left sides.

In a study of letter carriers, Wells et al. [1983] evaluated the effect of a load carried on the shoulder. Letter carriers, who carry a load and walk, were compared to gas meter readers (who walk without carrying a load) and postal clerks. Utilizing information from telephone interviews, points were assigned to symptom characteristics such as frequency, length of episodes, and interference with work ability. Case definition required a report of recurrent shoulder pain with greater than 20 points. A subset of letter carriers had experienced an increased load during the previous year. (The Postal Service had increased maximum weight carried from 25 to 35 pounds, but not all locations had implemented this change.)

Strength of Association—Force and Shoulder MSDs

The studies are presented in alphabetical order in Table 3-2. Results of studies where ORs, or other measures of association, were specifically associated with a measure of exposure, are presented in the section on Exposure-Response Relationship.

Andersen and Gaardboe [1993a] found that current work as a sewing machine operator was associated with chronic shoulder pain (OR 1.72, 95% CI 1.17–2.55). Using multiple logistic regression analysis with age, gender, and repetitiveness as covariates, Chiang et al. [1993] found that high force exertions measured in the forearm were associated with shoulder girdle pain (OR 1.8, 95% CI 1.2–2.5). When tested in the same model with force and repetition, the interaction term for force times repetition was also significant (OR 1.4, 95% CI 1.0–2.0). Two factors could have resulted in an underestimation of the strength of association: (1) no requirement that symptoms have started on current job meant that some symptomatic workers may have transferred to lower risk jobs, and (2) no matching of health status and exposure status by side (left, right, or both) may have caused non-differential misclassification. For supraspinatus tendinitis, Herberts et al. [1984] calculated a prevalence rate ratio (PRR) for plate-workers versus office clerks of 16.2 (90% CI 10.9–21.5) "under the assumption that missing data had the same characteristics as those considered." The absence of specific exposure information was a major limitation of this study.

The age-adjusted OR associated with osteoarthritis of the acromioclavicular joint was 2.16 (95% CI 1.14–4.09) (right side) and 2.56 (95% CI 1.33–4.93) (left side) for manual construction workers versus foremen [Stenlund et al. 1992]. Because there was a lower participation rate among bricklayers and blasters, self-selection into the study because of having symptoms could have resulted in overestimation of the strength of association. While some of the items handled required a bilateral lift (e.g., jackhammer), other loads may have been specific to the right or left hand. Because the exposure measure did not separate load by sides, non-differential misclassification may have caused underestimation of the strength of association.

Consistency of Association: Force and Shoulder MSDs

Despite different outcome and exposure measures, all of the studies had positive associations. Each study used a different case definition, ranging from relatively mild symptoms to radiographic evidence of osteoarthritis, and a different measure of exposure. Chiang et al. [1993] used EMG measures of forearm flexor muscle activity. Wells et al. [1983] evaluated the effect of a direct load on the shoulder. Stenlund et al. [1992] used an estimate of the cumulative, lifetime load carried. Andersen and Gaardboe [1993a] compared sewing machine operators to a referent population. However, positive and significant associations were found, regardless of the measure of health outcome or exposure.

Temporal Relationship: Force and Shoulder MSDs

All of the studies of forceful exertions used a cross-sectional study design. To increase the likelihood that shoulder symptoms were caused or aggravated by current exposure, Chiang et al. [1993] required that symptoms had occurred within the previous 30 days.

Wells et al. [1983] used several analytical methods to increase confidence in a relationship between carrying the increased load and having shoulder disorders. The use of age, the number of years on the job, and previous heavy work experience as covariates when performing analysis of covariance helped ensure that the difference in the proportion of shoulder disorders between letter carriers with and without the increased load was related to current exposure rather than past peak exposures or cumulative duration. Although baseline symptom status in the group with the increased load could not be obtained, there was no significant difference in the prevalence of shoulder problems between the two groups when results were adjusted for the amount of weight currently carried. Therefore, the difference in symptom prevalence was likely related to the load increase rather than prior differences in symptom status. The cross-sectional studies are consistent with exposure occurring before the onset of the shoulder MSDs.

Exposure-Response Relationship

When sewing machine operators were compared with an external control population, there was a trend of increasing ORs for chronic shoulder pain with increasing duration of work as a sewing machine operator [Andersen and Gaardboe 1993a]. The OR for 0–7 years was 1.38 (95% CI 0.86–2.39), for 8–15 years it was 3.86 (95% CI 2.29–6.50), and for >15 years it was 10.25 (95% CI 5.85–17.94), while controlling for other factors including age and current exposure.

Chiang et al. [1993] found a significant increasing trend in the prevalence of shoulder girdle pain from Group I (low force, low repetitiveness) to Group III (high force, high repetitiveness). However, the health outcome is not specific for shoulder tendinitis and the exposure categories combine increasing force, as measured in the forearm flexor muscles, and increasing repetitiveness.

In the study of bricklayers and blasters, and acromioclavicular osteoarthritis, Stenlund et al. [1992] found that for the left side, ORs increased with the level of lifetime load lifted. For a lifetime load of 710–24,999 tonnes versus less than 710 tonnes, the left side OR was 7.29 (95% CI 2.49–21.34), and for greater than 25,000 tonnes versus less than 710 tonnes, the left side OR was 10.34 (95% CI 3.10–34.46).

For severe, but not disabling, shoulder pain, the OR for letter carriers versus postal clerks was 3.6 (95% CI 1.8–7.8) [Wells et al. 1983]. For those letter carriers who had experienced a weightload increase within the previous year, versus postal clerks, the OR was 5.7 (95% CI 2.1–17.8). Furthermore, letter carriers who had experienced the weightload increase had significantly more shoulder problems than those whose bag weight had not been increased. If letter carriers tend to keep the mail-bag strap on one shoulder, the fact that the side of the load was not matched with the side of the shoulder problem could have resulted in non-differential misclassification and an underestimation of the strength of association. However, some of the health effects may have been related to activation of contralateral muscles involved in stabilizing the shoulder girdle [Winkel and Westgaard 1992].

Coherence of Evidence

High shoulder muscle force requirements can cause increased muscle contraction activity, which may lead to an increase in both muscle fatigue and tendon tension, and may possibly impair microcirculation as well.

Force may also be related to a static load on shoulder muscles. Sjøgaard et al. [1988] found that muscular fatigue will occur at EMG levels as low as 5% of maximal voluntary contraction (MVC) if sustained for 1 hour. Other studies have demonstrated that when the period of muscle contraction is extended to more than an hour, the endurance limit of force may be as low as 8% MVC [Jonsson 1988]. Workers performing repetitive work with the hands and wrists, while maintaining static upper arm elevation may experience fatigue even at low load levels. Jonsson [1988] reported that many constrained work situations are characterized by static load levels near or exceeding 5% MVC, even when characterized by a fairly low mean muscular load.

Because the five studies reviewed had a considerable diversity of exposure assessment approaches and health outcomes, there is insufficient epidemiologic evidence to conclude that forceful exertions are associated with rotator cuff or bicipital tendinitis. The one study that used shoulder tendinitis as the health outcome reported a strong association related to job category (OR for plate-workers versus clerks: 16.2 (95% CI 10.9–21.5), but did not describe or measure specific exposure risk factors [Herberts et al. 1984]. One of the reviewed studies did present evidence for an association between acromioclavicular osteoarthrosis and cumulative, lifetime load on the shoulder muscles [Stenlund et al. 1992]. Another study reported a significant association between severe shoulder pain and a direct shoulder load [Wells et al. 1983].

POSTURE

Definition of Awkward Posture for Shoulder MSDs

For the shoulder, a relaxed, neutral posture is one in which the arm hangs straight down by the side of the torso. As the arm is flexed, abducted, or extended, the included angle between the torso and the upper arm increases. In one study, postures in which the included angle was equal to or greater than 45 degrees required substantial supraspinatus muscle activity, while deltoid muscle activity underwent a pronounced increase as the angle of shoulder flexion or abduction increased from 45 to 90 degrees [Herberts et al. 1984]. As the arm is elevated, the space between the humeral head and the acromion narrows such that mechanical pressure on the supraspinatus tendon is greatest between 60 and 120 degrees of arm elevation [Levitz and Iannotti 1995]. While there is a continuum of severity from an included angle of 30 degrees to a maximally abducted arm, postures with shoulder abduction or flexion past 60 degrees are considered awkward.

Studies Reporting on the Association of Awkward Postures and Shoulder MSDs

Six of the reviewed studies reported results on the association between awkward postures and shoulder tendinitis [Baron et al. 1991; Bjelle et al. 1979; English et al. 1995; Herberts et al. 1981; Ohlsson et al. 1994, 1995] (Table 3-3, Figure 3-3). Seven additional studies reported results on the association between awkward postures and non-specific shoulder disorders [Sakakibara et al. 1995], non-specific shoulder symptoms [Hoekstra et al. 1994; Milerad and Ekenvall 1990; Schibye et al. 1995] combined neck-shoulder disorders [Bjelle et al. 1981; Jonsson et al. 1988; Ohlsson et al. 1995] or combined neck-shoulder symptoms [Kilbom and Persson 1987].

Studies Meeting the Four Evaluation Criteria

Four studies met all four of the evaluation criteria.

Using a prospective study design, Jonsson et al. [1988] assessed the health and exposure status of 69 electronics manufacturing plant employees at the beginning of the study and after one and two years. Employees who dropped out before completion of the study were compared to those who fully participated; there was no significant difference in medical status, working technique, or work history. Employees who had upper extremity disorders resulting in a physician visit or sick leave were excluded from the initial study group. The dependent variables related to health status were of two types: a change in symptom severity and being symptom free. Symptom status was assessed by interview and a physical examination by a physiotherapist. The symptoms severity index compiled data from the five body regions combined and was not specific for the shoulder region. Because the exposure was determined by direct observation for each individual, and clearly separated ergonomic risk factors by body region, it was still possible to evaluate associations likely to specifically involve the shoulder.

Kilbom and Persson [1987] and Kilbom et al. [1986] performed a study in which female employees in the electronics manufacturing industry were observed for a 2-year period. The health outcome of fatigue, ache, or pain in the neck, shoulder, or arm regions was based on symptoms information. Symptom severity was coded on the basis of its character, frequency, and/or duration. Changes in severity status at follow-up evaluations were used as the dependent variables in multiple regression analyses. Neck, shoulder, and upper arm posture was determined by computerized analysis (VIRA) of videotapes of individuals. Although the health outcome combined symptoms from different body regions, knowledge of biomechanical theory can be used to identify significant predictors related to the shoulder symptom severity.

Two of the reviewed studies in which tendinitis was the health outcome are Ohlsson et al. [1994, 1995]. For both studies, the authors reported that the examiners could not be completely blinded to exposed versus referent status, but that a standard protocol was followed and observer bias was likely to have been minimal. Because examiners were blinded to objective exposure measures, analyses testing associations between neck-shoulder disorders and specific postures would not have been biased [Ohlsson et al. 1995].

In a cross-sectional study, women in the fish industry were compared to a control population of women employed in municipal workplaces in the same towns [Ohlsson et al. 1994]. Diagnoses of shoulder disorders (e.g., tendinitis, acromioclavicular syndrome, frozen shoulder) were made on the basis of symptoms determined by interview and a physical exam. Exposure evaluation of each work task held by the fish industry population was evaluated with ergonomic workplace analysis (EWA). Ten different factors were rated on a scale from 1 to 5 and the combined ratings were used as a profile of the work task. Based on this profile, the authors reported that fish industry work was found to be “highly repetitive” and include “poor work postures.”

Ohlsson et al. [1995] compared a group of women who performed industrial assembly work to a referent group of women from a nearby town who were employed in jobs characterized as having varied and mobile work tasks. One examiner assessed signs and symptoms. The examiner was blinded to specific exposure information, but not completely blinded to factory worker versus referent group status. Shoulder tendinitis included supraspinatus, infraspinatus, and bicipital tendinitis. Another health outcome combined neck and shoulder disorders (tension neck, cervical syndrome, thoracic outlet syndrome, frozen shoulder, tendinitis, and acromioclavicular syndrome). In a descriptive assessment, it was reported that the work tasks in the study group involved repetitive arm movements with static muscular work of the neck and shoulder muscles. The percentage of time spent in specific upper arm postures was determined from videotaped observations of 74 (out of 82) workers. The average result from two independent videotape analyses was used. Posture category demarcations included 0, 30, and 60 degrees for arm elevation, and 30, 60, and 90 degrees for arm abduction.

Studies Not Meeting the Four Evaluation Criteria

Summaries of studies that specifically evaluated associations with shoulder tendinitis are presented next [Baron et al. 1991; Bjelle et al. 1979, 1981;

English et al. 1995; Herberts et al. 1981]. Summaries of other studies are presented in alphabetical order.

In the study by Baron et al. [1991], grocery store workers who performed the job of checker were compared to a non-checker group that performed a variety of other jobs (e.g., general stocking, working in the produce section, the bakery, salad bar, pharmacy, and courtesy counter). There was a low participation rate among non-checkers (55%), which could have resulted in an underestimation of the OR for checkers if symptomatic non-checkers were more likely to participate than those non-checkers without symptoms. The authors evaluated this possibility by performing a sufficient number of telephone interviews with non-participants to raise the non-checker participation rate for interviews to 85%. The OR for shoulder symptoms among the full participant population was similar to the OR for the full participant plus telephone interview population. The case definition was shoulder symptoms lasting at least one week or occurring at least once per month during the previous year that began while the worker was performing her current job and positive physical examination findings consistent with a shoulder tendinitis. Detailed descriptions of the checker jobs were presented based on both on-site and videotape analyses of a few representative workers per workstation. No videotaping of non-checkers was performed. Shoulder flexion and/or abduction ($90 degrees) was observed during a variety of different tasks performed by the checkers. The exposure measures used in statistical analyses were: (1) checker versus non-checker and, (2) for exposure-response assessment among checkers, the total number of months and the number of hours per week working as a checker.

Bjelle et al. [1979] compared cases with persistent shoulder pain to controls employed as manual workers. After an extensive medical evaluation, a diagnosis of bicipital and/or supraspinate tendinitis was made for a majority (12/17) of the cases. Physical workload was categorized in relation to sitting or standing posture, weight lifting, and carrying. The work height of the hands was categorized based on position relative to the acromion height, per individual. Placement of workers into exposure categories was determined by the combined efforts of each study participant and a physician.

Bjelle et al. [1981] compared cases with acute, non-traumatic shoulder-neck pain to age- and sex-matched, paired controls. An extensive physical examination was performed and workers with inflammatory rheumatoid diseases were excluded. To determine exposure, each case and control was filmed and a biomechanical analysis was performed to determine the duration and frequency of shoulder abduction or forward flexion greater than 60 degrees.

In a study by English et al. [1995], cases determined by medical diagnosis, and controls were selected from patients evaluated at specified orthopedic clinics. For statistical analyses, all diagnoses were grouped by anatomical site. The diagnoses for shoulder cases included rotator cuff injury, rupture of the long head of the biceps, shoulder capsulitis, and symptomatic acromioclavicular arthritis. It is assumed that shoulder tendinitis was included in this group. Exposure measures were determined by a standardized interview conducted by an interviewer who was, "unaware of the case-control status of the individual wherever this was possible."

In a study by Herberts et al. [1981], the prevalence of supraspinatus tendinitis was compared between welders and office workers. Tendinitis cases were based on a combination of symptoms reported on a nurse-administered questionnaire and a positive physical examination done by a physiotherapist. For welders, an "experienced physiotherapist" rated work-load on the shoulder as low, high, or very high; no description of the classification scheme was given.

Hoekstra et al. [1994] evaluated government office workers at two locations. The case definition for shoulder symptoms was symptoms that began after starting current job, lasting greater than one week, or occurring at least once per month during the past year with an intensity greater than two on a five point scale, and no preceding acute, non-occupational injury. A self-administered questionnaire was used to determine exposure to factors such as "perceived adequacy of adjustment of video display terminal (VDT)." Walk-through ergonomic evaluations of factors such as workstation surface height and furniture adjustability were used to provide descriptive differences between the two office locations.

Milerad and Ekenvall [1990] compared the prevalence of self-reported, non-specific shoulder symptoms between dentists and pharmacists. Dentistry, as a profession, was described as work "with the arms abducted and unsupported" whereas, pharmacists had "physically light and varied work."

In a prospective study by Sakakibara et al. [1995], the health status of a group of women farm workers was assessed during the performance of two different tasks, with a 1-month interval between the tasks. The health outcome was defined by self-assessed symptoms of shoulder stiffness and pain and a physical examination for muscle tenderness and joint pain on movement. Whether the examining physician was aware of the prior hypothesis regarding differing exposures between the two tasks (bagging pears versus bagging apples) was not stated. Exposure was based on self-report of the number of hours per day spent bagging, the number of pears or apples bagged per day, and the total number of days spent bagging each fruit. One worker was observed for 3 hours while performing each bagging job, with repeated goniometer measures of shoulder forward flexion angles done each minute. While there was no difference in the total number of days or number of hours per day spent bagging each fruit, significantly more pears than apples were bagged per day. The proportion of time spent with the angle of shoulder forward flexion greater than 90 degrees was significantly larger when bagging pears (75%) than when bagging apples (41%).

Schibye et al. [1995] performed a prospective study of a population of sewing machine operators in which the change in self-reported shoulder symptom status was compared with those sewing machine operators who continued to work and those operators that moved into other occupations (e.g., shop assistant, health care worker, and fishing industry worker).

Strength of Association—Awkward Posture and Shoulder MSDs

Results are presented in the section on Exposure-Response Relationship (Table 3-3, Figure 3-3) for studies where ORs, or other measures of association, were specifically associated with a measure of exposure.

Using data presented in the study by Ohlsson et al. [1994], for supraspinatus, infraspinatus, or bicipital tendinitis, the PRR for working in the fish industry (repetitive work, poor posture) versus the referent population was calculated as 3.03 (95% CI 2.0–4.6). For shoulder tendinitis alone, the PRR was calculated as 3.5 (95% CI 2.0–5.9). In the same study, the authors also interviewed a large group of former fish industry employees and found that a quarter of those workers who left employment had done so because of problems with their neck or upper limbs. This proportion increased with age and also occurred after a shorter duration of employment among the oldest workers. This evidence of a survivor bias highlights the importance of controlling for age. Higher risks were found for the workers less than 45 years old and these risks may be a more accurate assessment of the true risk.

Using data presented in the study by Ohlsson et al. [1995], for supraspinatus, infraspinatus, or bicipital tendinitis, the OR for being an assembly worker (repetitive arm movements with static load on shoulders) versus the referent population was 4.2 (95% CI 1.35–13.2). For neck-shoulder disorders, the OR for being an assembly worker versus the referent group was 5.0 (95% CI 2.2–11.0).

For shoulder disorders consistent with tendinitis, Baron et al. [1991] found that the OR for being a checker versus a non-checker was 3.9 (95% CI 1.4–11.0). Because non-checkers also performed work requiring awkward postures, the reported OR may underestimate the risk for checkers. Short stature (# 5'2") was associated with an elevated, but not statistically significant, OR for shoulder disorders (2.1, 95% CI 0.7–6.9). Because work-station height was fixed, it is likely that short stature workers experienced more frequent and/or more severe episodes of shoulder flexion and/or abduction.

The OR for work performed at or above acromion height (i.e., hands above the shoulder) versus work performed below acromion height was 10.6 (95% CI 2.3–54.9) [Bjelle et al. 1979]. In this study, all cases were patients who had been examined by the same physician. Placement of cases and controls into exposure categories was performed by each subject in collaboration with a physician who "had personal knowledge of the work involved in each case." Whether or not the physician who performed the clinical examinations is the same person as the physician involved in exposure classification is not stated. If this was the same person, a potential bias towards assigning cases to higher exposure categories could have resulted in overestimation of the strength of association. However, two other factors could have resulted in an underestimation of the strength of association. The exposure outcome was based on current work load without any stated restriction that cases' symptoms had started on their current job. If some of the cases, defined as having problems non-responsive to therapy lasting longer than 3 months, had transferred to a lower risk job, the strength of association may have been underestimated. Location of the disorder and exposure were not matched by side (left, right, or both) and this would have caused non-differential misclassification, resulting in some underestimation of the strength of association.

English et al. [1995] found that the risk of having a medically diagnosed shoulder condition was increased by repeated shoulder rotation with an elevated arm (OR 2.30, $p<0.05$). Non-differential misclassification due to a combination of complicated exposure definitions using a questionnaire, and the fact that analyses did not relate health outcomes and exposure on a temporal basis, or by left/right side, may have caused an under-estimate of the strength of association.

For supraspinatus tendinitis, Herberts et al. [1981] found that the PRR for welders (characterized as using awkward postures to perform overhead work) versus clerks was 18.3. However, in determining this PRR, the authors performed extrapolation based on an assumption that, "the drop-out group does not deviate from the examined group," without any data to support this assumption. To determine a more reliable indicator of risk, unextrapolated data presented in the study were used to calculate a crude OR=8.3 (95% CI 0.63–432). The office clerks were older than the welders, so that confounding by age may have caused an under-estimation of the strength of association.

In a study of teleservice employees, there was an association between reporting shoulder symptoms and working at one location versus another location; the OR was 4.0 (95% CI 1.2–13.1) [Hoekstra et al. 1994]. Descriptive differences between workstation design at the two locations provided a plausible explanation for this finding. At the higher risk location, the workstation surface was too high to serve as a keyboard support, there were nonadjustable chairs, and it was observed that "nonadjustable furniture universally promoted undesirable postures (i.e. elevated arms, hunched shoulders)." Having shoulder symptoms was also positively associated with using a non-optimally adjusted desk height (OR 5.1, 95% CI 1.7–15.5) and a non-optimally adjusted VDT screen (OR 3.9, 95% CI 1.4–11.5). Because exposure was self-reported without any indication of whether or not study participants had received education regarding good VDT workstation design, the phrase, "non-optimally adjusted," may have had various meanings to the study participants. This could have caused non-differential misclassification of exposure and an under-estimation of the strength of association. On the other hand, a possible reporting bias related to self assessment of both symptoms and exposure could have resulted in an overestimation of the strength of the association. A plausible explanation for the association between shoulder symptoms and these workstation design factors is that the non-optimally adjusted workstation components forced the employees to abduct the upper arms and/or hunch the shoulders.

For shoulder symptoms without concomitant neck symptoms, Milerad and Ekenvall [1990] found that the OR for being a dentist (work with both arms abducted) versus being a pharmacist was 3.8 (95% CI 1.2– 10.3). As with most cross-sectional studies, the survivor bias may have resulted in underreporting of the strength of exposure. Conversely, the exposed group may have had better recall of self-reported symptoms with a resultant overestimation of the OR.

In the study of farm workers by Sakakibara et al. [1995], the point prevalence of muscular tenderness in the shoulder regions (per physical examination) was significantly higher when performing pear bagging (48%) than when performing apple bagging (29%). The proportion of time spent with the shoulder in forward flexion greater than 90 degrees was significantly larger when bagging pears (75%) than when bagging apples (41%). Whether or not there was a recovery period between pear and apple bagging is not stated. If there was insufficient recovery after pear bagging, persistent muscle tenderness or increased susceptibility may have caused underestimation of the difference in shoulder disorder prevalence between these two work ta sks.

With the exception of the study by English et al. [1995], in which the strength of association may have been underestimated, for the studies in which the health outcome was shoulder tendinitis [Baron et al. 1991; Bjelle et al. 1979; Herberts et al. 1981; Ohlsson et al. 1994, 1995], the magnitude of association was strong. ORs ranged from 2.0 to 10.6. In none of these studies is it likely that nonoccupational factors such as sports activities or personal characteristics such as age explain these associations.

Consistency of Association

All but one of the reviewed studies relevant to posture and shoulder disorders found a positive association between shoulder disorders or shoulder symptoms and awkward shoulder posture. Awkward postures were consistently described as overhead work, arm elevation, and specific postures relative to degrees of upper arm flexion or abduction. This association was found in cross-sectional, case-control, and prospective studies among a great variety of types of work performed.

Temporal Relationship

It is important to determine whether symptoms or MSDs occur as a consequence of work-related exposures. This can be done most clearly with a prospective study design.

In the study by Jonsson et al. [1988], the percent of the work cycle spent with the shoulder elevated was negatively associated with remaining healthy (symptom free). Because workers with pre-existing shoulder conditions were excluded from study participation, the onset of new symptoms may have been associated with the daily and/or cumulative duration of exposure to elevated shoulder postures. In the study by Kilbom and Persson [1987], three of the work exposure variables that were strong predictors for a change to severe status at the 1- and/or 2-year follow-up evaluations were related to shoulder posture: (1) percent of work cycle time with arm abduction greater than 30 degrees, (2) percent of work cycle time with arm abduction greater than 60 degrees, and (3) percent of work cycle time with arm extension.

A few studies utilized techniques to improve the ability to detect possible relationships despite a cross-sectional study design. The case definition used by Baron et al. [1991] required that symptoms began while the worker was on the currently held job. Bjelle et al. [1979] filmed and analyzed the job held at the time the worker/case became symptomatic. The results of the prospective studies are similar to the cross-sectional studies. There is no evidence that shoulder disorders predicted the onset of exposure.

Exposure-Response Relationship

The level of an exposure can be described in two different ways. It may be related to the amount of exposure over a relatively short time period, such as a day or week, or it may be related to cumulative or life-time exposure over a number of years. Studies that tested associations related to daily or weekly variation in exposure are presented first, followed by studies that evaluated cumulative exposure by using independent variables, such as duration of employment or estimated lifetime exposure.

Four studies have some evidence of exposure-response relationships. Baron et al. [1991] found a significantly larger OR for shoulder disorders among employees working greater than 25 hours/wk as a checker compared to those working less than 20 hours/wk. Bjelle et al. [1981] found that the duration of hours worked per day with the shoulder flexed or abducted >60 degrees was significantly higher ($p<0.025$) for cases with neck-shoulder disorders than for controls. Ohlsson et al. [1995] found that neck and shoulder disorders among assembly workers were significantly associated ($p<0.05$) with the percent of time spent with the shoulder abducted or elevated >60 degrees. Although it is more difficult to detect associations with homogenous exposure, this association was significant despite very little variability in exposure to arm abduction greater than 60 degrees. While the analysis among assembly workers was performed without controlling for age, there is no evidence to suggest that older workers were more likely to be on high exposure jobs, and therefore a substantial bias is unlikely.

When comparing fish industry workers to the reference population, Ohlsson et al. [1994] found that among those workers younger than 45 years, the ORs for disorders of the neck and shoulders were significant and increased with duration of employment (0–5 years, OR 3.2; 95% CI 1.5–7.0) (>5 years, OR 10; 95% CI 4.5–24). Ohlsson et al. [1995] found a decreasing trend when they compared OR after stratifying the factory workers by employment duration (<10 years, OR 9.6; 10–19 years, OR 4.4 and $20 years: 3.8). Given the cross-sectional study design, this finding could be an artifact caused by the survivor bias (i.e., workers with disorders left, while symptom-free ‘survivors’ stayed; see Table 3-5). The assumption of a survivor bias is based on the finding that 28% of a group of former assembly workers reported pain in the musculoskeletal system as their reason for leaving employment at the factory. In the study by Schibye et al. [1995], improvement in shoulder symptoms among those who were no longer sewing machine operators appeared greater at follow-up, but was not significant. The fact that many of those who left sewing jobs moved into industries such as health care and fishing, where awkward postures and high force loads may occur, might explain why a large difference between sewing machine operators and non-sewing machine operators was absent. These four studies provide some support for the relationship between shoulder abduction and shoulder MSDs.

Coherence of Evidence

Discussions of the probable influence of workplace exposure factors in the pathophysiology of localized muscle fatigue, myalgia, and tendinitis have been presented by a number of authors [Bjelle et al. 1981; Hagberg 1984; Herberts and Kadefors 1976; Herberts et al. 1984; Levitz and Iannotti 1995]. Posture is important: when the arm is raised or abducted, the muscle activity in supraspinatus and other muscles increases, and the supraspinatus tendon comes in contact with the undersurface of the acromion. The mechanical pressure on the tendon from the acromion is greatest between 60 and 120 degrees of arm elevation. [Levitz and Iannotti 1995]. The degree of upper arm elevation is also important in the onset and intensity of localized muscle fatigue in the trapezius, deltoid, and rotator cuff muscles. [Hagberg 1981; Herberts and Kadefors 1976; Herberts et al. 1984]. In a laboratory study, EMG signals from these muscles were analyzed. The supraspinatus muscle was found to be highly active at $45 degrees of abduction. The deltoid muscle underwent a pronounced increase in activity as shoulder flexion or abduction increased from 45 to 90 degrees [Herberts et al. 1984]. The earlier sections on Coherence of Evidence also discussed the rate of fatigue and role of impaired micro-circulation in shoulder tendinitis.

Overall, there is epidemiologic evidence for a relationship between repeated or sustained shoulder postures with more than 60 degrees of flexion or abduction and shoulder MSDs. There is evidence for both shoulder tendinitis and nonspecific shoulder pain. The evidence for increased risk of MSDs due to specific shoulder postures is strongest when there is a combination of exposures to several physical factors such as force and repetitive work. An example of this combination would be holding a tool while working overhead. The strength of association was positive and consistent in the six studies that used diagnosed cases of shoulder tendinitis, or a combination of symptoms and physical findings consistent with tendinitis, as the health outcome [Baron et al. 1991; Bjelle et al. 1979; English et al. 1995; Herberts et al. 1981; Ohlsson et al. 1994, 1995]. Only one [Schibye et al. 1995] of the thirteen studies failed to find a positive association with exposure and symptoms or a specific shoulder disorder. However, in this study discontinuing employment as a sewing machine operator was associated with a reduction in neck and shoulder symptoms. While most of the studies that considered specific shoulder postures as an exposure variable were cross-sectional, the two prospective studies found that the percent of work cycle spent with the shoulder elevated [Jonsson et al. 1988] or abducted [Kilbom et al. 1986; Kilbom and Persson 1987] predicted change to more severe neck and shoulder disorders. While there is insufficient evidence to develop a quantitative exposure-disorder relationship, three studies reported a significant association with shoulder flexion or abduction greater than 60 degrees [Bjelle et al. 1981; Kilbom and Persson 1987; Ohlsson et al. 1995]. Among the studies for which shoulder tendinitis was the health outcome, the largest ORs were associated with work above acromion height [Bjelle et al. 1979;

Herberts et al. 1981]. These results are consistent with the current models for the pathophysiology of shoulder tendinitis and stressful shoulder muscle activities. In none of these studies does "age," an important personal characteristic associated with shoulder tendinitis, explain the positive results. Most of the studies controlled for a variety of confounders, such as occupational sports activities in their analyses. In summary, there is evidence that repeated or sustained shoulder abduction or flexion is associated with shoulder tendinitis, and the evidence is stronger for highly repetitive, forceful work.

VIBRATION

Three of the studies evaluated exposure to low-frequency vibration found in industrial settings (Table 3-4, Figure 3-4). Because of the small number of studies, the full outline used for the sections on repetition, force, and posture will not be repeated here. The study by Stenlund et al. [1992] is summarized in the section on force. Vibration exposure occurred in one of the three job categories: rock blaster. The exposure outcome, lifetime exposure to vibration expressed in hours, was determined from a weighted summary of the number of self-reported hours using specific tools. However, because the rock blaster job category was also the only one where workers performed heavy lifts several times per day, the authors concluded that, "vibration exposure is indivisible from static load and heavy lifting in the present data." When both cumulative lifting exposure and cumulative vibration exposure were included in the same multivariate model of an association with acromioclavicular osteoarthrosis, the OR for lifting and right- side osteoarthrosis remained significant while the weaker ORs for vibration became non-significant.

In the study by Stenlund et al. [1993], the same population of bricklayers, rock blasters, and foremen described in Stenlund et al. [1992] were evaluated to determine whether signs of tendinitis or muscle attachment inflammation in the shoulders were related to lifetime work load, years of manual work, lifetime exposure to vibration, or job title. The case definition for "signs of shoulder tendinitis" was pronounced (i.e., grade 3 out of 3) pain upon palpation of the muscle attachment or pronounced pain in response to isometric contraction of any of the rotator cuff muscles or the biceps muscle. The case definition of "clinical entity of tendinitis" was "signs of shoulder tendinitis" plus the subject's report of shoulder pain during the past year. Using multivariate models that included age and hours spent in arm intensive sports activities, a significant association with cumulative vibration exposure was found when it was tested in isolation from the other exposure variables. For "clinical entity of tendinitis" the OR for the left side was 1.86 (95% CI 1.00–3.44) and the OR for the right side was 2.49 (95% CI 1.06–5.87). For "signs of shoulder tendinitis" the OR for the left side was 1.66 (95% CI 1.06–2.61) and the OR for the right side was 1.84 (95% CI 1.10–3.07). When cumulative vibration exposure was tested in the same model with cumulative lifting load, significant associations were not found for either variable. Several factors could have resulted in an underestimation of the strength of association: (1) bricklayers or rock blasters with tendinitis may have been more likely to leave their jobs than foremen, (2) subjects may have had difficulty recalling exposure throughout their lifetimes, (3) the inability to separate exposure by left and right sides. These factors may have caused nondifferential misclassification. Most important is the authors' observation that vibration exposure occurred through the used of hand-held, heavy tools (e.g., jack-hammers) and thus is intertwined with exposure to a static load on the shoulders (from stabilizing the upper extremity while using the tool) as well as being associated with the heavy lifting tasks performed by rock blasters.

In a cross-sectional study by Burdorf and Monster [1991], riveters and control subjects in an aircraft company were investigated for vibration exposure and self-reported symptoms of pain or stiffness in the shoulder. Riveters were exposed to hand-arm vibration from working with hand drills, riveting hammers, bucking bars, and grinders. Controls were manual workers selected from the machine shop, maintenance, and welding departments in the same factory. In order to focus on the effect of vibration alone, a walk-through survey was performed to confirm that there were "no striking differences in dynamic and static joint loads during normal working activities." Participation was 76% among riveters and 64% among controls. An analysis of non-respondents revealed that controls with health complaints were more likely to have participated than those without, while riveters with health complaints were less likely to have participated. The health outcome, determined by a self-administered questionnaire, was shoulder pain or stiffness occurring for at least a few hours during the prior year. Only subjects who reported having no symptoms before starting their present work were included in logistic regression analyses. The vibration transmitted by hand-tools was measured and weighted according to International Standards Organization (ISO) standards. Tool vibration profiles and time-work studies of riveters and controls were used to determine daily vibration exposure for each group. For riveters, on the basis of daily tool operating time, the equivalent frequency-weighted acceleration for a period of 4 hours was 2.8 m s^{-2}. For controls, it was 1.0 m s^{-2}. Using a multiple logistic regression model that included age, there was a weak association between shoulder symptoms and the number of years riveting (0.05# p<0.10). When the age-adjusted ORs for riveters compared to controls were plotted by the duration (in years, from 0 to 20) of riveting, the slope for shoulder symptoms was very gradual, with ORs ranging from 1.0 to 2.0. While the results of the analysis of non-respondents described above suggest that the strength of association may have been underestimated, the reported associations are weak and it is unlikely that the response bias would have resulted in a large increase in the magnitude of association.

There is insufficient evidence for an association between shoulder tendinitis and exposure to segmental vibration. In four separate evaluations, stratified by "signs of tendinitis" (positive physical examination findings), "clinical entity of tendinitis" (signs plus symptoms), left and right side, Stenlund et al. [1993] found an association between shoulder tendinitis and vibration exposure to segmental vibration; the range of ORs was from (OR for right side 1.66, 95% CI 1.06–2.61) (OR for left side 1.84, 95% CI 1.10–3.07). However, work with vibration exposure also placed a large, static load on shoulder muscles so that the effects of forceful shoulder muscle exertions could not be separated from vibration.

ROLE OF CONFOUNDERS

Shoulder MSDs are multifactorial in origin and may be associated with both occupational and non-occupational factors. The relative contributions of these covariates may be specific to particular disorders. For example, the confounders for non-specific shoulder pain may differ from those for shoulder tendinitis. Two of the most important confounders or effect modifiers for shoulder tendinitis are age and sport activities. Most of the shoulder studies considered the effects of age in their analysis. Some studies considered sport activities [Baron et al. 1991; Stenlund et al. 1993; Jonsson et al. 1988; Kilbom et al. 1986]. Some studies also used multivariate methods to simultaneously adjust for several confounders or effect modifiers. For example, Ohlsson et al. [1995] found that for shoulder/neck diagnoses, repetitive work was the strongest predictor 4.6 (95% CI 1.9–12); age, muscle tension, and stress/worry tendency were also significant predictors. It is unlikely that the majority of the positive associations between physical exposures and shoulder MSDs are due to the effects of non-work confounders.

CONCLUSIONS

There are over 20 epidemiologic studies that have examined workplace factors and their relationship to shoulders (MSDs). These studies generally compared workers in jobs with higher levels of exposure to workers with lower levels of exposure, following observation or measurement of job characteristics. Using epidemiologic criteria to examine these studies, and taking into account issues of confounding, bias, and strengths and limitations of the studies, we conclude the following:

There is **evidence** for a positive association between highly repetitive work and shoulder MSDs. The evidence has important limitations. Only three studies specifically addressed the health outcome of shoulder tendinitis and these studies investigated combined exposure to repetition with awkward shoulder postures or static shoulder loads. The other six studies with significant positive associations dealt primarily with symptoms. There is **insufficient evidence** for a positive association between force and shoulder MSDs based on currently available epidemiologic studies. There is epidemiologic **evidence** for a relationship between repeated or sustained shoulder postures with greater than 60 degrees of flexion or abduction and shoulder MSDs. There is evidence for both shoulder tendinitis and nonspecific shoulder pain. The evidence for specific shoulder postures is strongest where there is combined exposure to several physical factors like holding a tool while working overhead. The strength of association was positive and consistent in the six studies that used diagnosed cases of shoulder tendinitis, or a combination of symptoms and physical findings consistent with tendinitis, as the health outcome. Only one [Schibye et al. 1995] of the thirteen studies failed to find a positive association with exposure and a specific shoulder disorder or symptoms of a shoulder disorder.

This is consistent with the evidence that is found in the biomechanical, physiological, and psychosocial literature.

There is **insufficient evidence** for a positive association between vibration and shoulder MSDs based on currently available epidemiologic studies.

Table 3-1. Epidemiologic criteria used to examine studies of shoulder MSDs associated with repetition

Study (first author and year)	Risk indicator (OR, PRR, IR, or *p*-value)*,†	Participatio n rate $70%	Physical examinatio n	Investigator blinded to case and/or exposure status	Basis for assessing shoulder exposure to repetition
Met all four criteria:					
Chiang 1993	1.6[†]	Yes	Yes	Yes	Observation or measurements
Kilbom 1986, 1987	NR[†,‡]	Yes	Yes	Yes	Observation or measurements
Ohlsson 1994	3.5[†]	Yes	Yes	Yes	Observation or measurements
Ohlsson 1995	5.0[†]	Yes	Yes	Yes	Observation or measurements
Met at least one criterion:					
Bjelle 1981	NR[†]	NR	Yes	Yes	Observation or measurements
English 1995	2.3[†,§]	Yes	Yes	Yes	Job titles or self-reports
Sakakibara 1995	1.7[†]	Yes	Yes	NR	Job titles or self-reports
Met none of the criteria:					
Ohlsson 1989	3.4[†]	NR	No	NR	Job titles or self-reports

[*]Some risk indicators are based on a combination of risk factors—not on repetition alone (i.e., repetition plus force, posture, or vibration). Odds ratio (OR), prevalence rate ratio (PRR), or incidence ratio (IR).

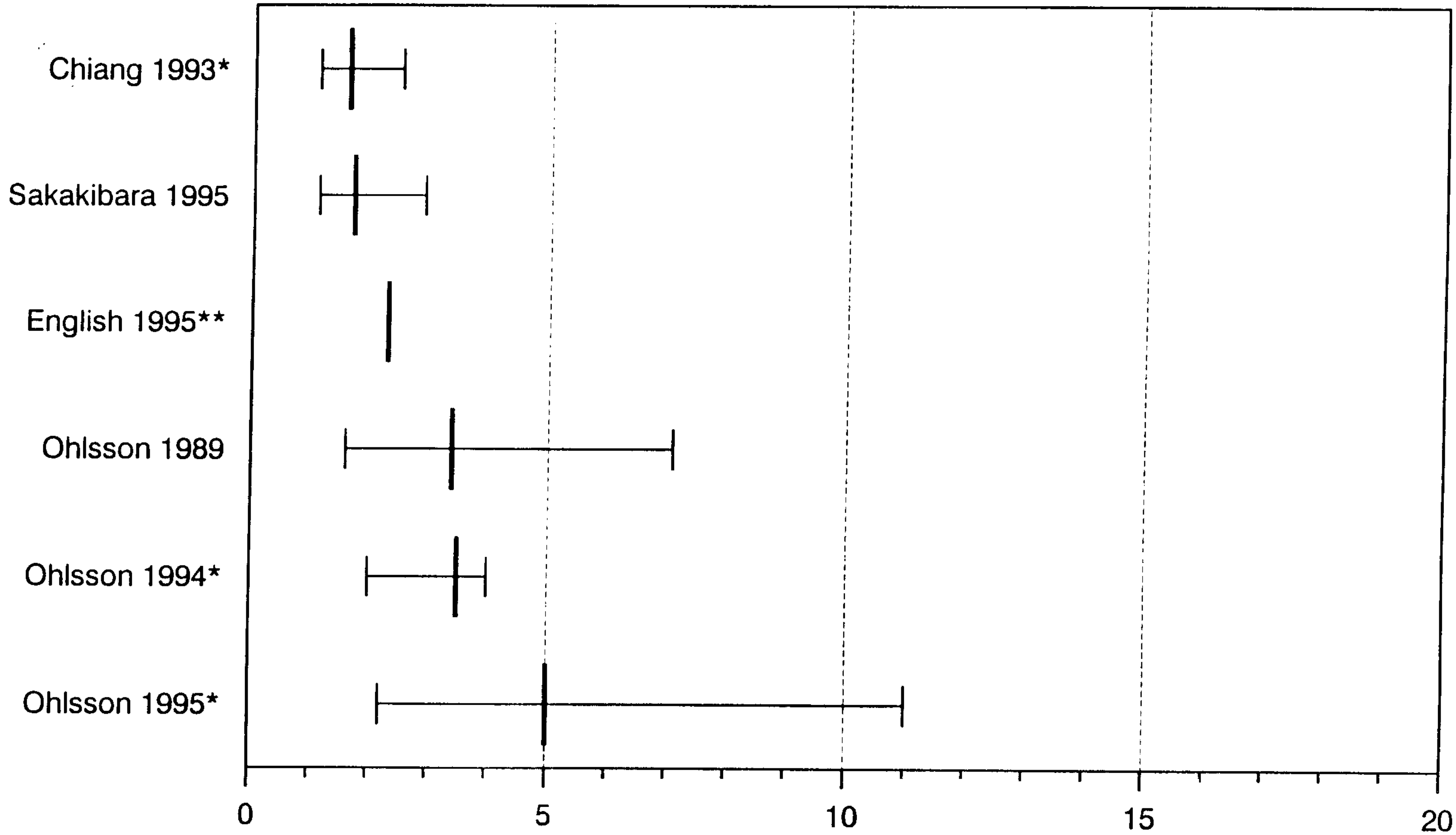
[†]Indicates statistical significance. If combined with NR, a significant association was reported without a numerical value.

[‡]Not reported.

[§]Repeated shoulder rotation with elevated arm.

Figure 3-1. **Risk Indicator for "Repetition" and Shoulder Musculoskeletal Disorders**

(Odds Ratios and Confidence Intervals)



* Studies which met all four criteria.

**Risk indicator reported without confidence limits.

Note: Two studies indicated statistically significant associations without reporting odds ratios. See Table 3-1.

Table 3-2. Epidemiologic criteria used to examine studies of shoulder MSDs associated with force

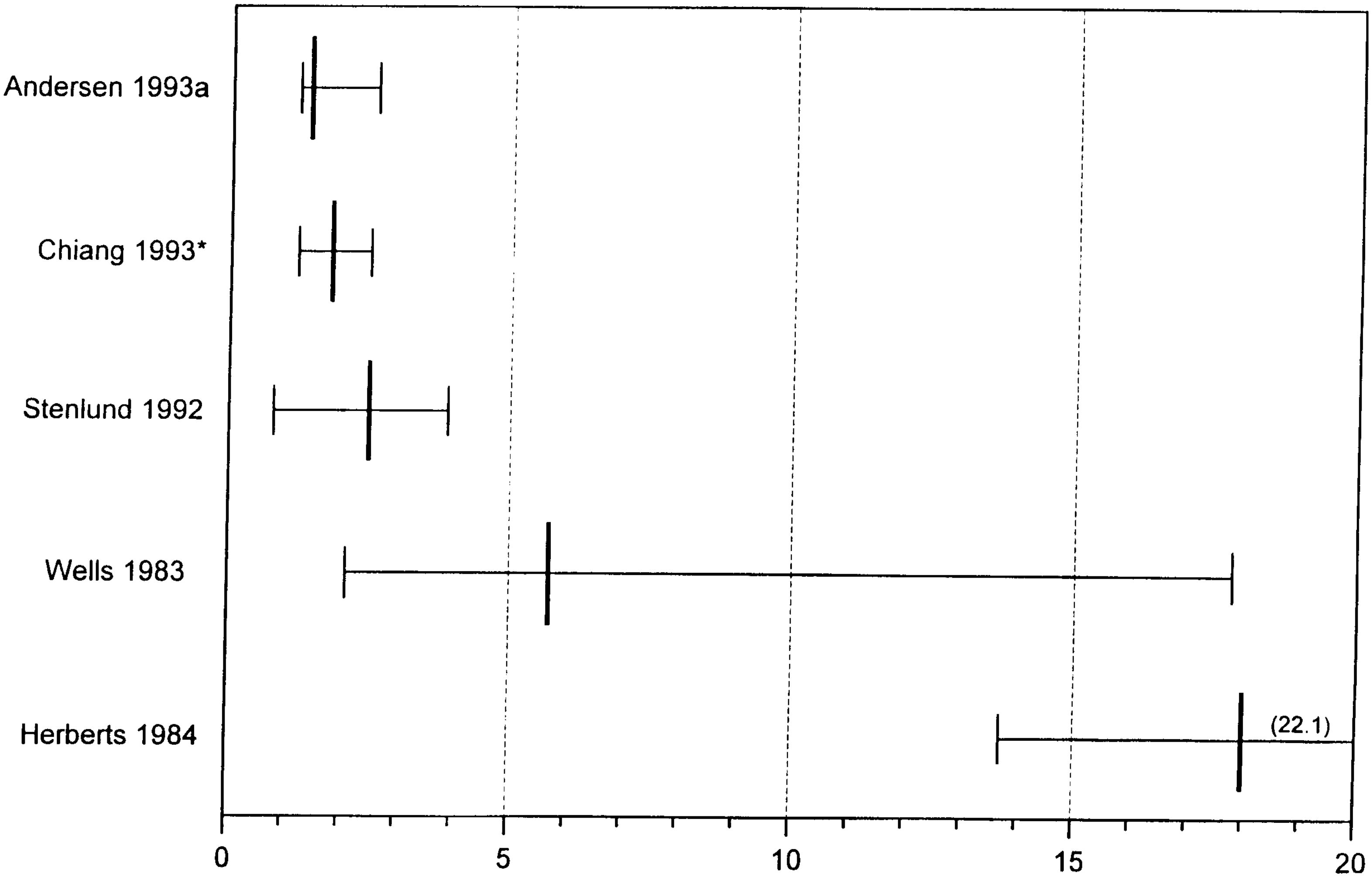
Study (first author and year)	Risk indicator (OR, PRR, IR or *p*-value)*,†	Participation rate $70%	Physical examination	Investigator blinded to case and/or exposure status	Basis for assessing shoulder exposure to force
Met all four criteria:					
Chiang 1993	1.8†	Yes	Yes	Yes	Observation or measurements
Met at least one criterion:					
Andersen 1993a	1.38–10.25†	Yes	No	Yes	Job titles or self-reports
Herberts 1981, 1984	15–18†	NR‡	Yes	NR	Job titles or self-reports
Stenlund 1992	2.2–4.0†	Yes	Yes	Yes	Job titles or self-reports
Wells 1983	5.7†	Yes	No	NR	Job titles or self-reports

*Some risk indicators are based on a combination of risk factors—not on force alone (i.e., force plus repetition, posture, or vibration). Odds ratio (OR), prevalence rate ratio (PRR), or incidence ratio (IR).

†Indicates statistical significance.

‡Not reported.

Figure 3-2. **Risk Indicator for "Force" and Shoulder Musculoskeletal Disorders**
(Odds Ratios and Confidence Intervals)



* Studies which met all four criteria.

Table 3-3. Epidemiologic criteria used to examine studies of shoulder MSDs associated with posture

Study (first author and year)	Risk indicator (OR, PRR, IR, or *p*-value)*,†	Participation rate $70%	Physical examination	Investigator blinded to case and/or exposure status	Basis for assessing shoulder exposure to posture
Met all four criteria:					
Jonsson 1988	NR†,‡	Yes	Yes	Yes	Observation or measurements
Kilbom 1986, 1987	NR†	Yes	Yes	Yes	Observation or measurements
Ohlsson 1994	3.5†	Yes	Yes	Yes	Observation or measurements
Ohlsson 1995	5.0†	Yes	Yes	Yes	Observation or measurements
Met at least one criterion:					
Baron 1991	3.9†	No	Yes	Yes	Observation or measurements
Bjelle 1979	10.6†	NR	Yes	No	Observation or measurements
Bjelle 1981	NR†	NR	Yes	Yes	Observation or measurements
English 1995	2.3†,§	Yes	Yes	Yes	Job titles or self-reports
Herberts 1981	8.3	NR	Yes	NR	Job titles or self-reports
Hoekstra 1994	5.1†	Yes	No	Yes	Job titles or self-reports
Milerad 1990	2.4†	Yes	No	NR	Job titles or self-reports
Sakakibara 1995	NR†	Yes	Yes	NR	Observation or measurements
Schibye 1995	NR	Yes	No	NR	Job titles or self-reports

*Some risk indicators are based on a combination of risk factors—not on posture alone (i.e., posture plus force, repetition, or vibration). Odds ratio (OR), prevalence rate ratio (PRR), or incidence ratio (IR).

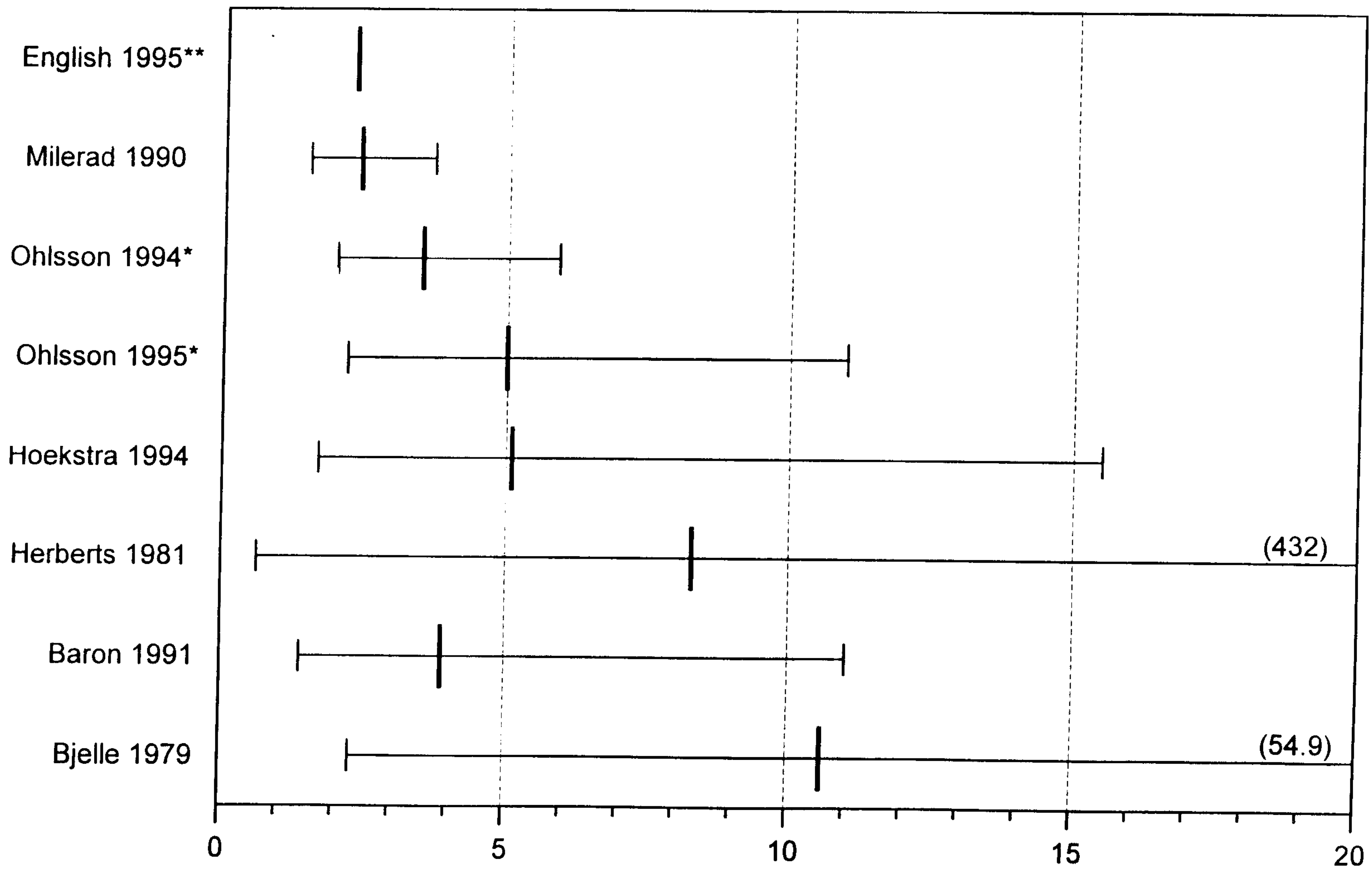
†Indicates statistical significance. If combined with NR, a significant association was reported without a numerical value.

‡Not reported.

§Repeated shoulder rotation with elevated arm (p< 0.05 level, most of study used 0.01 level).

Figure 3-3. **Risk Indicator for "Posture" and Shoulder Musculoskeletal Disorders**

(Odds Ratios and Confidence Intervals)



* Studies which met all four criteria.
**Risk indicator reported without confidence limits.
Note: Four studies indicated statistically significant associations without reporting odds ratios. See Table 3-3.

Table 3-4. Epidemiologic criteria used to examine studies of shoulder MSDs associated with vibration

Study (first author and year)	Risk indicator (OR, PRR, IR, or *p*-value)*†	Participatio n rate $70%	Physical examination	Investigator blinded to case and/or exposure status	Basis for assessing shoulder exposure to vibration
Met at least one criterion:					
Burdorf 1991	1.5	No	No	NR‡	Observation or measurements
Stenlund 1992	2.2–3.1†	Yes	Yes	Yes	Self-reports, weight of tools
Stenlund 1993	1.7–1.8†	Yes	Yes	Yes	Job titles or self-reports

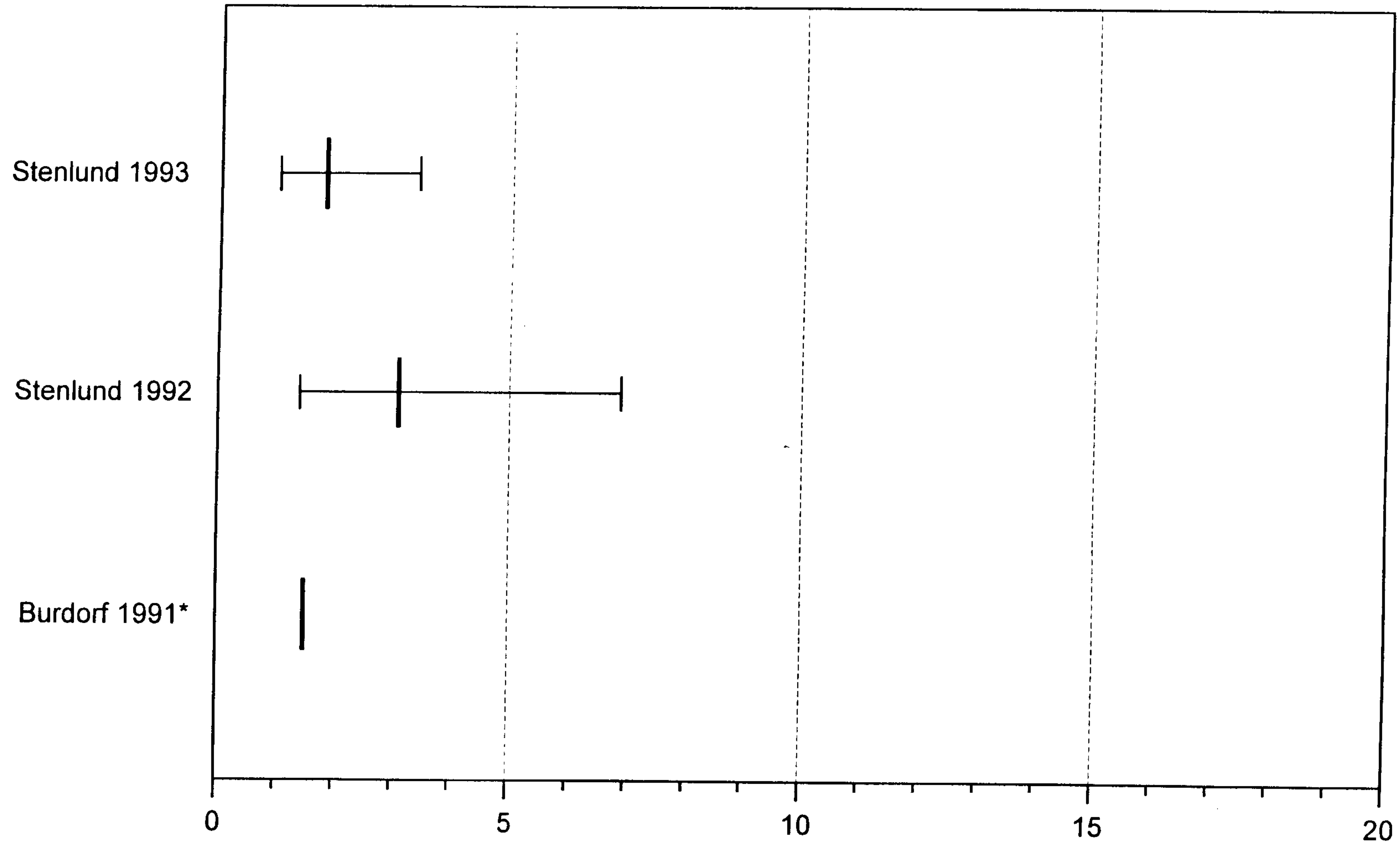
*Some risk indicators are based on a combination of risk factors—not on vibration alone (i.e., vibration plus force, posture, or repetition). Odds ratio (OR), prevalence rate ratio (PRR), or incidence ratio (IR).

†Indicates statistical significance.

‡Not reported.

Figure 3-4. **Risk Indicator for "Vibration" and Shoulder Musculoskeletal Disorders**

(Odds Ratios and Confidence Intervals)



* Risk indicator reported without confidence limits.

Table 3-5. Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Andersen and Gaardboe 1993a	Cross-sectional	424 female sewing machine operators (SMO), compared to 781 females from the general population of the region and internal referent group of 89 females from the garment industry.	Outcome: Case of chronic shoulder pain was defined as continuous pain lasting for a month or more after beginning work and pain for at least 30 days within the past year. Exposure: Categorization broken down according to current occupational status by job title. Classification into exposure groups based on author's experiences as occupational health physicians and involved crude assessment of exposure level and exposure repetitiveness. High exposure jobs were those involving high repetition/high force or high repetition/low force or medium repetition/high force. Medium exposure jobs were those involving medium repetition/low force and low repetition and high force. Low exposure jobs were low repetition/low force. For the analysis, "length of employment as a sewing machine operator" was considered the variable of interest, the rest were confounders.	Shoulder pain: Sewing machine operators, 25.2%	8.5%	3.21	1.68-7.39	Participation rate: 78.2%. Examiners blinded to case status. Respondents excluded if had previous trauma to neck, shoulder, or arms or had inflammatory disease at time of response. ORs adjusted for age, having children, not doing exercise, socioeconomic status, smoking, and current neck/shoulder exposure. Age-matched exposure groups and controls. Presented study as "general survey of health in the garment industry" to minimize information bias.
				Years of exposure: 0-7=12.3%		1.56	0.76-3.75	
				8-15=33.7%		4.28	2.14-10.0	
				>15=57.1%		7.27	3.82-16.3	

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Andersen and Gaardboe 1993b	Cross-sectional	From a historical cohort of 424 sewing machine operators, 120 were randomly selected and 82 exposed workers were categorized by number of years of employment: 0 to 7 years, 8 to 15 years and greater than 15 years. These were compared to a referent group of 25 auxiliary nurses and home helpers. A total of 107 subjects participated.	Outcome: Measured by health interview and exam of the neck, shoulder and arm. Case of chronic pain was defined as continuous pain lasting for a month or more after beginning work and pain for at least 30 days within the past year. Physical examination: Restricted movements in the cervical spine and either palpatory tenderness in cervical segments or irradiating pain or tingling at maximum movements or positive foraminal test. Exposure: Exposure categorization broken down according to current occupational status by job title. Classification into exposure groups based on author's experiences as occupational health physicians and involved crude assessment of exposure level and exposure repetitiveness. High exposure jobs: Involved high repetition/high force or high repetition/low force or medium repetition/high force. Medium exposure jobs involved medium repetition/low force and low repetition and high force. Low exposure jobs were low repetition/low force.	Rotator cuff syndrome: Number of workers by exposure time in years: 0-7: 1; 8-15: 6; >15: 11	Controls: 1	Chi sq for trend=9.51, $p<0.01$		Participation rate: 78.2%; logistic regression limited to a combined neck/shoulder case definition. Age-matched exposure groups and controls. Examiners blinded to control/subject status. Controlled for age, having children, not doing leisure exercise, smoking, socioeconomic status. Poor correlation between degenerative X-ray neck changes and cervical syndrome. Most frequent diagnosis among study group was "cervicobrachial fibromyalgia" significant for test of trend with exposure time in years. Chronic neck pain vs. palpatory findings: Sensitivity: 0.85; Specificity: 0.93.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Baron et al. 1991	Cross-sectional	124 Grocery checkers using laser scanners (119 females, 5 males) compared to 157 other grocery workers (56 females, 101 males). Excluded 18 workers in meat, fish, and deli departments, workers under 18, and pregnant workers.	Outcome: Based on symptom questionnaire and physical exam. (1) Rotator cuff syndrome—pain with resisted abduction or deltoid palpation (2) Bicipital tendinitis—pain on Yergason's maneuver. Case defined as having positive symptoms in shoulder and a positive physical exam of a particular body part. Symptoms must have begun after employment at the supermarket and in the current job; lasted one week or occurred once a month during the past year; and where there was no history of acute injury to body part in question. Exposure: Job category and estimates of repetitive and average and peak forces based on observed and videotaped postures, weight of scanned items, and subjective assessment of exertion.	Checkers: 15%	Other grocery workers: 7%	Checkers vs. others: OR=3.9	1.4-11.0	Participation rate: 85% checkers; 55% non-checkers in field study. Following telephone survey 91% checkers and 85% non-checkers. Examiners blinded to worker's job and health-status. Logistic regression model adjusted for duration of work. No difference in groups between age, gender, and hobbies so that these were not controlled for. Number of hr worked/week as a checker statistically significantly related to shoulder disorders for workers checking >25-hr/ /week (OR=3.5, *p*<0.05) (OR estimated from figure). Total repetitions/hr ranged from 1,432 to 1,782 for right hand and 882 to 1,260 for left hand. Average forces were low and peak forces medium. Multiple awkward postures recorded for upper extremities among cashiers. No statistical significance associated between duration of employment as a checker and shoulder MSDs.
				Checkers using scanners: 34%		Checkers using scanners vs. others: OR=8.6	1.0-72.2	
				Checkers 5'2" or less in height: 21%	Other grocery workers 5'2" or less in height: 13%	Checkers <5'2" vs. other grocery workers <5'2": OR=2.1	0.7- 6.9	

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Bergenudd et al. 1988	Cross-sectional	574 of 830 survey respondents participated in a health exam. In 1983, 1,070 residents of Malmö, Sweden, responded to questions on shoulder pain in a health survey as part of a longitudinal study begun in 1,938 of 1,542 residents.	Outcome: Based on symptom survey: Occurrence of shoulder pain lasting $24 hr during the last month and physical exam (joint motion, tenderness on palpation of supraspinatus, biceps, tendons and acromioclavicular joint). Exposure: Based on job classification; classified as: Light physical demands (white collar) =275; Moderate physical demands (nurses, light industry)=237; Heavy (blue collar, e.g., carpenters, bricklayers)=50.	Prevalence of occupational workload in subjects with shoulder pain Heavy work: 11% Moderate work: 49% Light work: 40%		ô	ô	Participation rate: 69%. Unknown whether examiners blinded to case status. Analysis stratified by gender. Only 9% of workers included in study were in the Heavy Physical Demands Jobs category, compared to 49% in Light category and 42% in moderate category. Only 1% of females were in Heavy Physical Demand Jobs category. Sick leave due to shoulder pain was restricted to males in jobs with moderate or heavy physical demands (*p*<0.05) (data not shown in article). At one year follow-up, 61 (77%) of 79 subjects with shoulder pain re-examined. 35 had continued shoulder pain. Misclassification of work categories a possibility: Likely no observation of job tasks performed.. No differences in overall physical demands of jobs among subjects with shoulder pain compared to those without shoulder pain, but females with signs of supraspi-natus tendinitis more often had jobs with physical demands. Authors state that shoulder pain may be related to intelligence in males in this study; "more talented" males had less shoulder joint symptoms. We question author's conclusions. Females showed significant association with shoulder pain and dissatis-faction. No association with relation to family or friends or level of life success. Author states both groups of females rated their life success low, and subjects with shoulder pain did not rate level of success differently.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Bernard et al. 1994	Cross-sectional	Of a total population of 3,000 workers in the editorial, circulation, classified advertising, and accounting departments, 1,050 were randomly selected for study and 973 participated; 894 responded to the shoulder questions. Cases fulfilling shoulder definition compared to non-cases.	Outcome: Health data and psychosocial information were collected using a self-administered questionnaire. Definition: Presence of pain, numbness, tingling, aching, stiffness or burning in the shoulder occurring $once a month or 7 days continuously within the past year, reported as moderately severe. The symptom must have begun during the current job. Workers with previous injuries to the relevant area were excluded. Exposure: Based on observation of work activity involving keyboard work, work pace, posture, during a typical day of a sample of 40 workers with symptoms and 40 workers without symptoms. Exposure to work organization and psychosocial factors based on questionnaire responses.	17% (case) 3% (case with daily pain)	õ	Female: OR=2.2 Perceived lack of decision making participation: OR=1.6 Years at the newspaper: OR=1.4 Perceived increased job pressure: OR=1.5	1.5-3.3 1.2-2.1 1.2-1.8 1.0-2.2	Participation rate: 93%. Examiners blinded to case and exposure status. For calculation of the ORs of the psychosocial scales, the responses were divided into quartiles, then the 75th percentile was compared to 25th percentile. Model adjusted for race, age, gender, height, psychosocial factors, medical conditions. Age, height, hr typing away from work, other medical conditions were not found to be significant. In a sub-analysis of jobs with comparable number of males and females, there were no significant factors related to shoulder MSDs.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Bjelle et al. 1979	Case-control	17 cases of shoulder tendinitis from a population of male industrial workers who were patients at an occupational health center. These 17 were chosen from 20 consecutive male patients from 6 industries and had been suffering from pain over a period of >3 months in one or both shoulders. 34 non-cases were matched for age and workshop.	Outcome: Cases were non-responsive to analgesics, non-steroidal anti-inflammatory agents, physiotherapy, and outcome measured by exam. Case defined as shoulder pain lasting >3 months with no resolution post-treatment. Exposure: Defined as work with hands at or above shoulder level. 3 classes work performed: (A) with hands below shoulder or acromion height, (B) at or above acromion 3 to 8 times/day (<1/hr plus for duration >1 min) (C) $8 times at or above acromion ($1/hr. plus duration >1 min). Exposure assessed by interview and physician observation and knowledge of work. Electromyographs on 15 cases. Open muscle biopsies on 11 cases.	With work at or above shoulders: 65%	With work at or above shoulders: 15%	10.6	2.3-54.9	Participation rate: Not reported. Matched for age, gender and workshop. Three of the 20 were diagnosed with inflammatory rheumatoid diseases not previously diagnosed, 17 had no inflammatory rheumatic disease. Mean age (53 years) of cases significantly older than other workers (37.6 years). Myopathic signs not found on EMG or muscle biopsies. Muscle enzymes (creatine phosphokinase and/or aldolase) were elevated in 6 cases. Present and previous employment, physical workload not different between cases and referents. Work performed with hands above acromion height significantly greater for cases than referents. 2-year follow-up showed that only 8 cases working in the same or less heavy types of work, 7 of these had slight shoulder complaints.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Bjelle et al. 1981	Case-control	20 workers of industrial plant consecutively seen at health clinic with acute, nontraumatic shoulder-neck pain. Of these, 13 were not due to causative disease or malformation. These 13 were compared to 26 controls, matched on age, gender and place of work.	Outcome: Physician evaluated all patients with acute non-traumatic shoulder-neck pains referred to the outpaient clinic of the rheumatology department. Each patient had to undergo an extensive clinical examination, including local anaesthesia for the definition of pain location. Exploratory puncture of the glenohumeral joint was performed in patients with tenderness over the joint. Exposure: Anthropometric and Isometric muscle strength were tested with strain gauge instruments. Patients asked to perform their max-mal efforts. Measurements made for the following contractions: shoulder elevation at the acromion, abduction and forward flexion of the shoulder joints at neutral position and semipronated. Grip strength measured by vigorimeter. Video recording of arm movements at work. Shoulder loads estimated from videos. Consisted of measuring the duration and frequency of shoulder abduction or forward flexion of >60°. EMG measurement of shoulder load during assembly work on 3 patients and 2 healthy volunteers. Muscular load level determination made by computer analysis of myo-electric amplitude.	6 with right shoulder tendinitis: 46%	No Controls with tendinitis: 0%	Cases had significantly longer duration and higher frequency of abduction or forward flexion than controls, $p<0.001$. Cases had significantly higher shoulder loads than controls. Median number of sick-leave days significantly different between cases and controls ($p<0.01$).		Participation rate: Not reported. Video analyses were done blinded to case status. No significant difference between cases and controls in anthropometry. Isometric strength test: controls significantly stronger in 6 of 14 tests but probably influenced by pain inhibition in cases. No significant difference in cycle time (9 vs. 12 min) between cases and controls. The supraspinatus muscle showed a significant change of the mean power frequency ($p<0.05$) towards lower levels, indicating a fatiguing process for four of the five investigated assemblers during work.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Burdorf and Monster 1991	Cross-sectional	194 riveters exposed to vibration compared to 194 workers in the same plant with little or no exposure to vibration.	Outcome: Standardized Nordic questionnaire, pain or stiffness. Exposure: Employed >12 months, not exposed to hand/arm vibration. Observation, time-work studies, measurements of vibrating tools. No shoulder measurements. Occupational history treated as dichotomous variable with "1" for heavy physical work.	31%	20%	1.5		Participation rate: Riveters=76%, controls=64%. Examiners blinded to exposure or case status: Not reported. Confounders controlled for included height, weight, and smoking habits. Age and height significantly different between groups. Years of riveting work associated with pain or stiffness in shoulder (0.05#*p*#0.10). Follow-up of nonrespondants showed no difference in age or work experience. Sick leave significantly different.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	RR, OR, or PRR	95% CI	Comments
Burt et al. 1990	Cross-sectional	836 Newspaper employees in the Editorial Department and selected jobs in the Advertising, Circulation, Data Processing, and Finance Departments from 4 company locations, (460 female and 376 male). Cases compared to non-cases.	Outcome: Based on symptom questionnaire. Case defined as pain, aching, stiffness, burning, numbness or tingling in shoulder lasting >1 week or occurring one time/month in the past year. Symptoms must have begun on current job; no previous accident or acute injury to the joint, no related systemic disease. Exposure: Based on questionnaire and job sampling. Exposure variables included work time spent typing on computer; typing speed; keyboard type; hr worked/week; workload; number of years worked.	Time spent typing: 50% Typing Speed: Slow: 6% Moderate: 11% Fast: 15%	42%	õ Typing Speed: Moderate: 2.6 Fast: 4.1 Pre-existing Arthritis: OR=2.3 Dissatisfied with job: OR=2.3	õ 1.1-5.9 1.8-9.4 1.2-4.4 1.2-4.3	Participation rate: 81%. (Authors note that those out on assignment or ill or on vacation counted as non-participants.) Number of workers in number of non-typing jobs not reported. Reporters characterized by high periodic demands (deadlines) although they had high control and job satisfaction. Job analysis found significant correlation (r=0.56) between reported average typing time/day and observed 8 hr period of typing (p<0.0001). Length of employment and symptoms in shoulder not significant.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Chiang et al. 1993	Cross-sectional	207 fish processing workers, 67 males and 140 females, divided in 3 groups: (I) Low force, low repetition (comparison group, n=61); (II) High force or high repetition (n=118); (III) High force and high repetition (n=28).	Outcome: Shoulder girdle pain as defined by Anderson (1984) (the painful condition of the shoulder with limitation of movement, which may occur in association with tension neck or merge with pain in the suprascapular or upper dorsal regions). Symptoms in these regions occurring in last 30 days and physical exam findings of $two tender points or palpable hardenings which may either be caused or aggravated by work conditions. Exposure: Assessed by observation and recording of tasks and biomechanical movements of three workers each representing one of 3 study groups. Highly repetitive jobs with cycle time k=<30 sec or >50% of cycle time performing the same fundamental cycles. Hand force estimate from EMG recordings of forearm flexor muscles. Classification of workers into 3 groups according to the ergonomic risks of the shoulders and upper limbs: Group I: Low repetition and low force; Group II: Low repetition or low force; Group II: High repetition and high force.	Prevalence of Physician-observed Disorders: Group II: 37% (male 31%; female 39%) Group III: 50% (male 50% female 50%)	Prevalence of Physician-observed Disorders: Group I: 10% (male 9% female 10%)	Repetitive movement of the upper limb (Rep): OR=1.6 Sustained forceful movement of the upper limb (force): OR=1.8 Rep times force: OR=1.4 Age: OR=1.0 Gender: OR=1.1	1.1-2.5 1.2-2.5 1.0-2.0 0.9-1.1 0.7-1.7	Participation rate: Not quantified; however, authors stated that "all of the workers who entered the fish processing industry before June 1990 and were employed there full-time were part of the cohort." Of the 232 employees who agreed to participate, 207 met study criteria. Examiners blinded to exposure status. ("Workers examined in random sequence to prevent observer bias.") Workers with hypertension, diabetes, history of traumatic injuries to upper limbs, arthritis, collagen disease excluded from study group. Eight plants used in study. Authors reported "no plant effect". Case definition based on physician diagnosis not significantly different from definition based on symptoms in Groups II : 37% vs. 44% or Group III: 50% vs. 50%. Group I about 2/3 the prevalence (10% vs. 15%). Dose-response for physician observed shoulder girdle pain among three exposure groups. Dose-response for physician observed shoulder girdle pain by gender in three exposure groups. Logistic model controlled for age and gender. Significant trend found for duration of employment and exposure group in workers <12 months, 12 to 60 months, but not in workers employed >60 months.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
English et al. 1995	Case-control	Cases: n=580; 174 males and 406 females with diagnosed soft tissue conditions of the upper limb at 2 orthopedic clinics; ages 16 to 65 years.	Outcome: Based on standard diagnosis for rotator cuff injury; rupture of the long head of biceps, shoulder capsulitis, symptomatic acromioclavicular arthritis.	Frequency of shoulder problems		Per 5 years of age: 1.4	1.2-1.5, $p<0.01$	Participation rate: 96%. Administered questionnaire blinded to case status.
				Rotator cuff: 8.3%	ð	For elbow flexion: 0.4	0.2-0.8, $p<0.01$	Controlled for age, height, gender, weight, whether MSD was due to an accident, study center.
		Controls: 996 controls; 558 males and 438 females attending the same clinics; diagnosed with conditions other than diseases of the upper limb, cervical or thoracic spine; ages 16 to 65 years.	Exposure: Based on self-reported risk factors at work for musculoskeletal disorders concentrating on detailed components of movements and activities at work: awkward postures, grip types, wrist motions, lifting, shoulder postures, static postures, hand tool use, and job category.	Rupture of long head of biceps: 0.3%	ð	Per hr of total daily elbow flexion: 1.1	0.9-1.2, $p<0.01$	Total daily exposure to elbow flexion did not contribute to shoulder injury.
				Shoulder capsulitis: 3.6%	ð	Repeated shoulder rotation with elevated arm: RR=2.3	Not reported $p<0.05$	Risks highest for female hairdressers. "Repetitive" defined as a frequency of >once/min of 14 specific movements.
			Questionnaire obtained information on repetitive movements of the upper limb: Shoulder flexion, shoulder rotation with elevated arm, keeping the whole arm raised >1 min, shoulder rotation with elbow flexed.	Symptomatic acromioclavicular arthritis: 0.2%	ð	Wrist rotation at low rates: RR=0.18	Not reported $p<0.05$	Sporting activities, hobbies; average hr of driving/week; whether claim for compensation made were analyzed in models.
						Wrist rotation with increasing rates: RR=2.02/30 reps/min.	Not reported $p<0.05$	Jobs with pinching between thumb and forefinger protective against shoulder disorders. May reflect hand movement and exertion with no shoulder movement or exertion. Small number of subjects/group limits power to detect significant differences.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Flodmark and Aase 1992	Cross-sectional	58 industrial workers making ventilation shafts (51 males and 7 females) compared to symptom prevalence in 170 blue-collar workers in Örebro, Sweden. Compared workers with symptoms to those workers without symptoms for risk factor analysis.	Outcome: Questionnaire survey using Nordic questionnaire for symptoms as to duration during last 12 months and during last 7 days, effect on work performance and leisure activities, and sick leave. Type A behavior assessed by Bortner questionnaire. Exposure: No objective measurements.	Symptoms in past 12 months: 40%	Symptoms in past 12 months: 23%	2.2	1.4-4.4	Participation rate: 87%. Aim of the study was to further investigate relationship between Type A behavior and musculoskeletal symptoms. The Bortner Score for Type A behavior significantly higher for those with shoulder symptoms than those without. No difference in headache, tiredness, sleeping, irritation, lack of concentration or problems with eyes, nose, stomach, skin. Authors suggest that Type A persons more likely to ignore symptoms to minimize their potential effect on work capacity.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Hales and Fine 1989	Cross-sectional	Of 96 female workers employed in 7 high exposure jobs in poultry processing, 89 were compared to 23 of 25 female workers in low exposure jobs.	Outcome: By questionnaire: Period Prevalence: Symptoms in last 12 months. Case defined as: pain, aching, stiffness, numbness, tingling or burning in the shoulder, and symptoms began after employment at the plant; were not due to a previous injury or trauma to the joint; lasted >8 hr; and, occurred 4 or more times in the past year.	Any symptom of the shoulder: 49% (high exposure group)	43% (low exposure group)	1.2	0.7-2.0	Participation rate: 91%. Examiner blinded to case and exposure status. Analysis adjusted for age and duration of employment.
				Period prevalence for shoulder case: 19%	4%	3.8	0.6-22.8	Although shoulder MSDs surveyed by questionnaire, exposure assessment was based on hand/wrist exposure, so that risk for shoulder may not be accurate.
			Point Prevalence: Determined by physical exam of the upper extremity using standard diagnostic criteria case must also fulfill symptom definition (listed above).	Point prevalence for shoulder case: 7%	4%	0.9	0.1-7.3	High exposure departments: Breast trim, thigh debone, leg cut/disjoint, tender cut, knuckle cut, breast, knuckle cut, thigh fat trim.
			Exposure: Observation and walk-through; jobs categorized as High exposure and Low exposure based on estimated hand force and hand repetition, not shoulder exposure.					Lower exposure departments: Breast, thigh, or quality control inspectors.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

				MSD prevalence				
Study	**Study design**	**Study population**	**Outcome and exposure**	**Exposed workers**	**Referent group**	**RR, OR, or PRR**	**95% CI**	**Comments**
Hales et al. 1994	Cross-sectional	533 Telecommunication workers (416 females and 117 males) in 3 offices, employed $6 months. "Cases" fulfilling shoulder WRMSD definition compared to non-cases.	Outcome: Self-administered questionnaire and standard physical examination; case defined as: pain, aching, stiffness, burning, numbness or tingling >1 week or >12 times a year; no previous traumatic injury to the area; occurring after employment on current job within the last year and positive physical exam: moderate to worst pain experienced with positive physical finding of the symptomatic joint. Exposure: Work practices and work organization assessed by questionnaire and observation; number of keystrokes/day. Physical workstation and postural measurements obtained but not used in final analyses.	Rotator cuff tendinitis: 6% (n=513) Bicipital tendinitis: less than 1% (n=516) Overall shoulder: 6%		Fear of replacement by computers: 1.5 Number of times arising from chair: 1.9	 1.1-2.0 1.2-3.2	Participation rate: 93%. Physician examiner blinded to worker case study. Logistic analysis adjusted for demographics, work practices, work organization, individual factors; electronic performance monitoring; DAO keystrokes; Denver DAO keystrokes/day. ORs for psychosocial variables represent risk at scores one standard deviation above mean score compared to risk at scores one SD below mean. Because of readjustments and changes of workstations during study period, measurements of VDT workstations considered unreliable and excluded from analyses. Number of hr spent in hobbies and recreational activities not significant. Although keystrokes/day was found to not be significant, data available was for workers typing an average of 8 words/min over 8-hr period. 97% of participants used VDT $6 hr/day, so not enough variance to evaluate hr of typing. Over 70 variables analyzed in models may have multiple comparison bias.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Herberts et al. 1981	Cross-sectional	131 male shipyard welders with >5 years of work experience compared to 57 male office clerks. All workers participated in the shipyard's medical program which offered medical exams every 5 years.	Outcome: Positive answers to questions about repeated occurrences of shoulder pain during work; shoulder stiffness that affected work and weakness in shoulder that affected work or weakness or numbness in arm or hand and participation in a follow up exam. Clinical examination with joint range of motion, active and passive and simultaneous pain analysis, rating of gross power in flexion, abduction and rotation, rating of tenderness to palpation. Exposure: Estimation of workload with assessment of the workplace into 3 groups very high, high or low. Static loading while holding tools; awkward postures; shoulder level or overhead work.	Supraspinatus tendinitis (ST) results of 23 welders called back for clinical follow-up exams: 16 welders had supraspinatus tendinitis. Shoulder Pain reports from the questionnaire: 27%	Shoulder Pain Prevalence from questionnaire: 1.8%	Prevalence rate ratio (PRR) of shoulder pain results from questionnaire, welders vs. office workers: PRR=15.2 PRR from estimated prevalence ("proportionation" of cases) reported in article: PRR=18.3	2.1-108 (90% CI) 14.7-22.1 (90% CI)	Participation rate: Not reported. Incidence estimated to be 15 to 20% a year. Welders with and without tendinitis were age-matched. We question the methods used to approximate the prevalence of shoulder tendinitis. Authors stated that they took into account the missing data in the investigation and assumed that the drop-out group did not deviate from the examined group, so they used "proportionation" to obtain the number of cases of supraspinatus tendinitis cases in the welders for calculations of prevalence rate ratios; number of supraspinatus tendinitis cases increased from 16 to 24. Number of years active welding, shoulder load, and welding years showed no significant difference. However, a sample size of 11 matched pairs may not have enough power to detect a difference. Turnover of shipyard welders mentioned at 33%. Shoulder tendinitis was not found to be associated with increasing age.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Herberts et al. 1984	Cross-sectional	131 male shipyard welders and 188 plate workers compared to 57 male office clerks. Welders and plateworkers chosen had >5 years of job experience. 23 symptomatic welders, 30 symptomatic plate workers compared to 18 asymptomatic welders and 30 plate workers by clinical exam. Age-matched pairs: 11 welders; 15 plateworkers.	Nurse-administered symptom questionnaire: Case defined as pain, weakness, stiffness in shoulder excluding effects originating from neck, plus clinical exam with tenderness, range of motion gross power measured by dynamometer. Exposure: Observation of jobs; workers compared by use of job title; EMG measurements of muscles of shoulder region. Electromyographic analysis of the shoulder muscle load completed on 9 volunteers to study the influence of hand tool mass and arm posture.	Questionnaire results, shoulder pain of the supraspinatus tendinitis type Welders: 27% Plateworkers: 32% Supraspinatus tendinitis results of 23 welders called back for clinical follow-up exams: 16 welders had supraspinatus tendinitis Supraspinatus tendinitis results of 30 plateworkers called back for clinical follow-up exams: 15 plateworkers had supraspinatus tendinitis	Questionnaire results, shoulder pain of the supraspinatus tendinitis type: Office worker: 2%	PRR=18.3 PRR=16.2	13.7-22.1 (90% CI) 10.9-21.5 (90% CI)	Participation rate: Not reported. Not mentioned whether examiners blinded to case or exposure status. Controls were matched for age and gender. Plateworkers with shoulder pain averaged 6 years older than welders with shoulder pain. EMG analysis using fine monopolar wire electrodes showed that in work where the hand was positioned overhead, the intramuscular pressure in the supraspinatus muscle had extremely high pressure levels compared to pressure levels in other skeletal muscles. Turnover rate of welders was 30%; may be explanation for lack of association with duration. Welding seen as static work; plateworking dynamic work.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Hoekstra et al. 1994	Cross-sectional	108 of 114 teleservice representatives working at 2 Government administration centers: A and B.	Outcome: Self administered questionnaire. Case defined as the presence of pain, numbness, tingling, aching, stiffness or burning in the shoulder, and no previous injury; symptoms began after starting the job; lasting >1 week or occurred once a month within the past year; reported as “moderate” or greater on a 5-point scale. Exposure: Observation of work stations, measurement and evaluation of work station; observation of postures.	Center A: 13%		õ	õ	Participation rate: 95%.
				Center B: 44%		4.0	1.2-13.1	Representatives perceived little control over actions of others; little participation in decision making; little freedom to regulate own activities. Perception that workload was high and variable.
				Non-optimally adjusted desk height work		5.1	1.7-15.5	Analysis controlled for gender and location and interactions checked.
				Non-optimally adjusted screen		3.9	1.4-11.5	Variables considered in logistic model included location, age, seniority, hr spent typing at VDT, hr on the phone, 3 chair variables, and perceived adequacy of: (1) chair adjustment, VDT screen, (2) keyboard adjustment, VDT screen, (3) desk adjustment; job control, workload variability. Center B location had nonadjustable work stations and mostly nonadjustable chairs causing elevated arms, hunched shoulders and other undesirable postures. Linear regression also performed on psychosocial variables in separate models for health outcomes of job dissatisfaction and mental and physical exhaustion (not for shoulder MSDs). Did not include non-work-related variables in analyses.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Hughes et al. 1997	Cross-sectional	104 male aluminum smelter workers: 62 carbon setters, 36 crand operators, 9 carbon plant workers. There were 14 workers who were not from selected jobs and were excluded.	Outcome: Symptoms occurring in the shoulder >once per month or lasting longer than 1 week in the previous year, no acute or traumatic onset; occurrence since working at the plant, no systemic disease. Physical examination: Active, passive, and resisted motions, pinch and grip strength, 128 Hz vibration sensitivity, two-point discrimination. Psychosocial scales from questionnaire based on Theorell and Karasek Job Stress Questionnaire, and on Work Apgar questionnaire used. Exposure: For carbon setters and crane operators (non-repetitive jobs) and modified job-surveillance checklist method was used. Job task analysis used a formula based on the relative frequency of occurrence of posture during tasks.	14.9% with positive symptoms and physical exam. 24% had symptoms in the elbow-forearm in the previous week.	õ	Model based on MSD defined by symptoms and physical exam Age: OR=0.93 Good health: OR=0.35 Low decision latitude: OR=4.0 Years of forearm twist: OR=46 Model based on MSD defined by symptoms Age: OR=0.96 Smoker: OR=0.41 Low decision latitude: OR=4.5 High Job demand: OR=3.0 Years forearm twist: 92	 0.8-1.0 0.1-0.87 0.8-19 3.8-550 0.8-0.98 0.1-1.4 1.3-16 0.7-13 7.3-4	Participation rate: carbon setters: 65%; crane operators: 56%; carbon plant: 33%. Examiners blinded to exposure and health status: Not reported. Analysis controlled for age, smoking status, sports and/or hobbies. Psychosocial data collected individually; physical factors based on estimates of each job. Job risk factors entered into the model for hand/wrist included (1) the number of years of handling >2.7 kgs./hand, (2) push/pull, (3) lift/carry, (4) pinching, (5) wrist flexion/extension, 60 ulnar deviation, and (7) forearm twisting. Health interview included information about metabolic diseases, acute traumatic injuries, smoking, hobbies. Low participation rate limits interpretation.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Ignatius et al. 1993	Cross-sectional	1,917 of 3,248 male postal employees completed an interviewer-administered questionnaire; 1,081 were letter delivery postmen compared to 836 other postal workers.	Outcome: history of symptoms and severity of recurrent joint pain as defined by Wells et al. [1983]. Exposure: work factors related to weight of letter bags, distance walked each day, use of transporting tools. Postmen carry/day an average load of 45 lbs; walked 4.5 km plus 1,300 steps for 3.7 hr/day.	Recurrent joint pain: 55.1% Severe joint pain: 12.0%	38.4% 6.2%	1.8 2.2	1.5 -2.2 1.5-3.1	Participation rate: 59% Severe shoulder pain associated with age, work experience, bag weight and walking time. Bags usually carried on one shoulder.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	Referent group	RR, OR, or PRR	95% CI	Comments
Jonsson et al. 1988	Prospec-tive	Electronics Workers (n=69 females) out of initial 96 workers. (See Kilbom et al. 1986 for initial study.)	Outcome: Three separate physical exams at yearly intervals (one initially) assessing tenderness on palpation, pain or restriction with active and passive movements; symptoms in previous 12 months with regard to character, frequency, duration, localization, and relation to work or other physical activities. Analyzed if score on any symptom of $2, on a 4 point scale; "severe" symptom score equals 4. Exposure: Carried out at outset of study: Maximum voluntary isometric contraction (MVC) of forearm flexors, shoulder strength, handgrip, heart rate using a bicycle ergometer and rating of perceived exertion. Videotaping performed for the analysis of working postures and movements. Reallocation tasks: Non sitting; no inspection of small details on printed circuit boards; standing and walking, occasionally sitting; caretaker work; surveillance of machinery; and assembling bigger and heavier equipment.	Severe shoulder disorders: 22% at 2nd exam After 1 year; 24%	Initially: 11% of subjects had shoulder MSDs 20% with unchan-ged working conditions	At 3rd exam during 3rd year of longi-tudinal study: 38 subjects reallocated to varied tasks had improved (16% of these had severe symptoms initially) significance at $p<0.05$ Those with unchanged working tasks deteriorated further (26%).		Participation rate: 72% of original group had 3 exams one year apart. 80% had 1st and 3rd year exams. Questionnaire included spare time physical activity, hobbies, perceived psychological stress at work, work satisfaction, number of breaks, rest pauses. Most of physiologic and ergonomic evaluations conducted only at outset of study. Low muscle strength not a risk factor for subsequent symptoms. Relative time spent with shoulder elevated negatively related to "remaining healthy" after both 1 and 2 years. Muscular strength and endurance not related to improvement nor remaining healthy. At 2nd and 3rd examination, there was a strong negative relationship between "remaining healthy" and satisfaction with colleagues. Predictors of remaining healthy were work without elevating the shoulders and satisfaction with work tasks. No mention of examiner being blinded to case status. Predictors of deterioration were previously physically heavy jobs, high productivity (after 1 year), and previous sick leave. Predictors of improvement were reallocation, physical activity in spare time, and high productivity (after 2 years).

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Kiken et al. 1990	Cross-sectional	294 Poultry Processors at 2 plants. Plant #1=174 Plant #2=120	Outcome: Period prevalence symptom in last 12 months by questionnaire. Case: Pain, aching, stiffness, burning, numbness or tingling in the shoulder, began after employment at the plant; not due to previous accident or injury outside work; lasted >8 hr and occurred 4 or more times in the past year.	Plant #1: Any symptom for shoulder case: 46%	28%	1.6	0.9-2.9	Participation rate: 98%. Examiners blinded to case and exposure status. Analysis stratified for gender and age.
				Period prevalence: 13%	3%	4.0	0.6-29	Higher exposure jobs (HE) were located in the receiving, evisceration, whole bird grading, cut up and deboning departments. Lower exposure jobs (LE) were located in the maintenance, sanitation, quality assurance and clerical departments.
			Point prevalence determined by physical exam. Rotator cuff defined as pain $3 on a 0 to 8 scale on active and resisted shoulder abduction. Case must fulfill symptom definition (listed above).	Point prevalence for shoulder case: 3%	0%	Indeterminate	õ	30% of workers involved in a job rotation program may have influenced associations made.
			Exposure: Determined by observation; level of exposure was based on exposure to repetitive and forceful hand motions, not shoulder.	Plant #2: Any symptom for shoulder case: 50%	30%	1.7	0.8 -3.3	Annual turnover rate close to 50% at plant 1 and 70% at plant 2 making survivor bias a strong possibility -- leading to underestimation of associations.
				Period prevalence: 14%	5%	2.8	0.4-19.6	
			Exposure measurements estimated for the hand and wrist region and *NOT* the shoulder area.	Point prevalence for shoulder case: 3%	0%	Indeterminate	õ	

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

				MSD prevalence				
Study	Study design	Study population	Outcome and exposure	Exposed workers	Referent group	RR, OR, or PRR	95% CI	Comments
Kilbom et al. 1986	Cross-sectional	106 of 138 female assemblers in two electronic manufacturing companies agreed to participate; 10 excluded because of symptoms in past 12 months. 96 underwent medical, physiological, and ergonomic evaluation. (See Jonsson et al. 1988, earlier in this table, for follow-up.)	Outcome: Three separate physical exams at yearly intervals (one initially) assessing tenderness on palpation, pain or restriction with active and passive movements; symptoms in previous 12 months with regard to character, frequency, duration, localization, and relation to work or other physical activities. Analyzed if score on any symptom of $2, on a 4 point scale; "severe" symptom score equals 4. Exposure: Carried out at outset of study: Maximum voluntary isometric contraction (MVC) of forearm flexors, shoulder strength, handgrip, heart rate using a bicycle ergometer and rating of perceived exertion. Videotaping during the representative part of working day from rear and side. Upper arm studied at rest and in 0 to 30E, 30 to 60E, 60 to 90E, in extension and >90E abduction. The shoulder recorded as resting or elevated; also frequency of changes in posture between different angular sectors/hr, duration of postures. Work cycle time and number of cycles/hr, time at rest for arm, shoulder, head.	MSD symptoms in the shoulder using a four point severity scale: None: 84% Slight: 5% Moderate: 7% Severe: 3%		Logistic Regression model (all variables significant at the *p*<0.05 level). Shorter stature Years of employment in electronics. Fewer total number of upper arm flexions/hr. Greater percentage of work cycle time with upper arm abducted 0 to 30E.		Participation rate: 77%. See Jonsson et al. 1988 for follow-up. No relation between maximal static strength and symptoms. Examiner blinded to case status. Questions included spare time physical activities, hobbies, perceived psychosocial stress at work, work satisfaction, number of breaks, rest pauses. 59% had no symptoms or only slight ones. There were no cases of shoulder tendinitis. Age showed a weak positive correlation. Years of employment, productivity, muscle strength were not related to symptoms. There was large inter-worker variation in working posture and working techniques. The authors followed up on the non-participants and found no significant differences from participants. The more dynamic working technique, the less symptoms.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Kvarnström 1983b	Cross-sectional and Case-control	112 cases of prolonged shoulder disorders identified in a workplace of 11,000 employees. The total number of employees was approximately half factory workers and half office workers. Case more than control study: Controls chosen at random from factory workers, matched for age and gender.	Outcome: Shoulder cases fulfilled the following: symptoms from shoulder was the main reason for inability to work, off work longer than 4 weeks, fatigue in one of both shoulders, pain in shoulder brought on by work and aching at rest were present, and Clinical examination demonstrated tenderness of the shoulder muscles, especially muscularis trapezius, levator scapulae, and/or infraspinatus and/or tenderness at the tendon insertions of the rotator cuff muscles. Muscle strength in shoulder assessed with regards to four functions Exposure: (1) Information obtained through interview: organization of work, physical work load, physical environment, psychosocial work environment, social and ethnic conditions, (2) detailed work history. Factors 0,1, or 2 given to different types of work depending on the workload borne by the shoulder. This factor multiplied by number of years spent at job, and products were added, (3) 2 company engineers graded the degree of monotony and repetitiveness in each job held by cases and controls.			Die casting machine operators (involved heavy work with repetitive movements of the shoulders): RR=5.4 Plastic workers: RR=2.2 Spray painters: RR=3.7 Surface treatment operators: RR=4.7 Assembly line workers: RR=5.2 Ergonomic experts' evaluation: cases had significantly more monotonous and repetitive work than controls.		Participation rate: Not reported. Examiners not blinded to exposure, but selection based on diagnosis of shoulder MSD. All 112 shoulder disorders occurred in laborers; none in office workers. RR for Swedish workers: 0.46; RR for immigrants: 3.1. All cases except one were paid piece rate. "Young persons significantly less ill than middled-aged." The following questionnaire responses were significantly different between cases and controls: Group piece rate, shift work, heavy work, monotonous, stressful, detrimental to health, heavy lifting, and unsuitable working conditions. 9 cases and 1 control cited poor relationship with supervisor. No difference in environmental condition, job content. Cases more likely to be married, have ill spouses, have children at home, work alternating shifts than controls. Work history showed no difference between points for cases and controls (see exposure column). Muscle strength bilaterally significantly lower in cases in four functions.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
McCormack et al. 1990	Cross-sectional	Manufacturing workers: packaging or folding workers (41 males, 328 females); sewing workers (28 males, 534 females); boarding workers (19 males, 277 females) compared to knitting workers (203 males, 149 females); non-office workers (204 males, 264 females) compared with knitting workers (203 males, 149 females). These groups were compared to a referent group consisting of non-office workers maintaining machinery, involved in transportation, or worked as cleaners and sweepers. None of the referent group used rapid repetitive movements comparable to the employees in the other job categories. 21, 25 and 36 operators from each group and 25 of 55 auxiliary nurses and home helpers (controls) participated in the study.	Outcome: Questionnaire and physical examination initially by nurse screening; if employee answered affirmative to question regarding symptoms in upper extremity and/or had any positive physical findings, then had physician examination. The term "shoulder condition" used to define abnormalities of shoulder; consisted of bursitis, bicipital tendinitis and impingement syndrome. Exposure: Based on observation of job activities; only the boarding workers had activities requiring reaching overhead (from personal communication with first author).	Packaging/ folding workers: 2.7%	non-office workers: 2.1%	1.3	0.5-3.8	Participation rate: 91%. Examiners not blinded to exposure status (information obtained from personal communication). 11 Physician examiners; inter-examiner potential problem acknowledged by authors. Questionnaire asked types of jobs, length of time on job, production rate, nature and type of upper extremity complaint and general health history. Age, sex, race, job category and years of employment not statistically significant with "shoulder conditions." Patients with objective diagnostic shoulder findings: Of 45 cases diagnosed: 25 graded as "mild", 19 graded as "moderate; 1 graded as severe.
				Sewing workers: 2.5%	2.1%	1.2	0.5-2.7	
				Boarding workers: 2.4%	2.1%	1.1	0.4-2.9	
				Knitting workers: 1.1%	2.1%	1.3	0.5-3.1	

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Milerad and Ekenvall 1990	Cross-sectional	99 Dentists randomly selected from Stockholm dentist registry who practiced $10 years compared to 100 pharmacists selected from all pharmacists in Stockholm.	Outcome: Based on telephone questionnaire: Shoulder symptoms at any time before the interview "lifetime prevalence." Further analyzed according to Nordic questionnaire as to duration during last 12 months and during last 7 days, effect on work performance and leisure activities, and sick leave. Exposure: Questionnaire included: (1) abduction of arm, particularly in sit-down dentistry, (2) static postures, (3) work hr/day.	Male: 36% Female: 67%	15% 28%	2.4 2.4	1.0 -5.4 1.5-3.7	Participation rate: 99%. Stratified analysis by gender.
				Neck and shoulder: 36%	17%	2.1	1.3-3.0	No difference in leisure time exposure, smoking, systemic disease, exposure to vibration. Symptoms increased with age in female dentists only.
				Neck and shoulder and upper arm: 16%	3%	5.4	1.6-17.9	Duration of employment highly correlated with age (r=0.84, 0.89). No relation between symptoms and duration of employment. Equal problems dominant and nondominant sides.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Ohara et al. 1976	Cross-sectional and Prospective	For cross-sectional study: 399 cash register operators compared with 99 office machine operators and 410 other workers (clerks and saleswomen). All female. For prospective study: 56 workers employed <7 months had testing pre- and post-intervention using questionnaire and physical exam. 86 operators, newly hired after interventions, also had evaluation after 10 months of working.	Outcome: Assessed by standard health inventory and medical examination (used clinical classification according to the committee on cervicobrachial disorders of the Japan Association of Industrial Health, in Table 3 in the paper). Periodic physical exam performed twice a year from 1973. Primary exams performed on 371 operators. 130 (35%) received detailed exams. Exposure: To repetitive movements relocating merchandise across counter and bagging, involved muscle activity of the fingers, hands, and arms; extreme and sustained postures. Interventions: (1) a 2-operator system, 1 working the register, one packing articles, changing roles every hr; (2) continuous operating time <60 min; max. working hr/day 4.5 hr; (3) 15- min resting period every hr; (4) electronic cash registers with light touch keyboard substituted for half of previously used mechanical cash registers.	Shoulder stiffness: Cashiers: 81% Shoulder dullness and pain: Cashiers: 49%	Shoulder stiffness : Office Workers: 72% Shoulder dullness and pain: Other workers: 68% Office workers: 30%	1.7 2.0 2.2	1.0-2.8 1.4-2.8 1.4-3.5	Participation rate: for prospective study = 100%. Participation rate: for cross-sectional study, not reported. Unknown whether examiners blinded to case status. Interventions did not reduce complaints in the shoulder region, but did improve symptoms in the arms, hands, fingers, low back, and legs. The lack of improvement in the shoulder region was stated to be due to the use of the same narrow check stands, unsuitable counter height, and necessity of continuous lifting of the upper limbs. Operators hired after the interventions and then examined after 10 months had less Grade I, II , or III occupational cervicobrachial disorders in examination than those hired before intervention. Only 14.5% with >3 years employment at worksite. Narrow work space and counter height not adjusted for height of worker.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Ohlsson et al. 1989	Cross-sectional	Electrical equipment and automobile assemblers (n=148), former female assembly workers who quit within 4 years (n=76) compared to randomly sampled females from general population (n=60).	Outcome: Based on questionnaire: Any shoulder pain, shoulder pain affecting work ability, and shoulder pain in the last 7 days. Exposure: Based on job category.	Shoulder pain in previous 12 months: 55%	45%	2.0	1.1-4.0	Participation rate: Not reported. Significant association for shoulder symptoms and medium and fast pace compared to slow pace but not very fast pace.
				Shoulder pain in previous 7 days: 38%	18%	3.4	1.6-7.1	Significant association with duration of employment (*p*=0.03), but much stronger for workers <35 years than workers >35 years.
				Work in auxiliary previous 12 months: 21%	10%	2.4	1.0-5.8	Significant interaction between age and employment. Older females employed for shorter periods had more symptoms than younger ones.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Ohlsson et al. 1994	Cross-sectional	Exposed Group: 206 of 247 females working in 13 fish processing plants participated. 322 females who left employment in the fish processing industry in the 10 years prior to the study. Comparison group: All 208 females employed in the same towns as the exposed; 71 were employed in day nurseries; 92 in offices; 42 caretakers of elderly; 3 gardeners.	Outcome: Defined by criteria from questionnaire and physical examination: standard diagnosis of frozen shoulder, supraspinatus tendinitis, infraspinatus tendinitis, bicipital tendinitis acromioclavicular syndrome. Exposure: Assessed by questionnaire (length of employment; psychosocial factors, physical factors) and by observational methods (Ergonomic Workplace Analysis) and NIOSH guidelines for lifting. Analyzed 10 items: work site, general physical activity, lifting, work postures and movements, job content, job restrictiveness, worker communication, difficulty of decision making, repetitiveness of the work, and attentiveness. 74 workers videotaped $10 min. from the back and sides. Average counts of two independent readers for frequencies, duration and critical angles of movement used.	Frozen shoulder: 2%	0.5%	4.1	0.5-37	Participation rate: 83%. No exposure information available to examiners, however, it was not possible to completely blind the study/referent group status. All activities (trimming of cod, packing fish and herring filleting) were found to be highly repetitive with poor working postures and fast movements by standardized "ergonomic workplace analysis" (EWA) methods; very few pauses in the work cycle; tasks not varied. Sports activities were highly associated with shoulder tendinitis (OR=4, 9) in multiple logistic regression analysis. In the control group, prevalences of upper limb disorders increased substantially with age. Among the exposed, the prevalence remained almost constant with age. Excess prevalence for exposed females most pronounced for females <45 years. There was a pronounced dose-response for disorders of the neck or shoulders vs. duration of exposure in the industry. No such associations seen in group >45 years. Authors explained as perhaps due to the "healthy worker effect," but, it would be more accurate to describe it as "survivor bias." Psychosocial work environment, stress and worry factors, tendencies towards muscular tension differed significantly between exposed and controls.
				Supraspi-natus tendinitis: 15%	5%	3.4	1.6-7.2	
				Infraspinatus tendinitis: 12%	3%	4.7	1.4-15.2	
				Bicipital tendinitis: 10%	4%	2.4	1.1-5.4	
				Acromiocla-vicular syndrome: 17%	6%	3.1	1.6-6.0	
						PRR of shoulder disorders: 2.95	2.2-4.0	
						PRR for suprapi-natus, infraspinatus and bicipial tendinitis: 3.03	2.0-4.6	
						PRR for suprapinatus and infraspinatus tendinitis alone: 3.5	2.0-5.9	

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Ohlsson et al. 1995	Cross-Sectional	Industrial Workers (n=82 females) exposed to repetitive tasks with short cycles mostly far <30 sec, usually with a flexed neck and arms elevated and abducted intermittently; 68 former workers (mean employment time 21 years) who had left the factory during the 7 years before the study; these workers were compared to 64 referents with no repetitive exposure at their current jobs (female residents of a nearby town currently employed as customer service, ordering and price marking in supermarkets, as office workers (no constant computer work) or as kitchen workers.	Outcome: Measured by physical exam and questionnaire. Frozen shoulder: Limited out-ward rotation and abduction. Infraspinatus, supraspinatus tendinitis: Local tenderness over tender insertion, pain with resisted abduction. Bicipital tendinitis: Pain with resisted elevation of arm, resisted flexion of elbow. Acromicoclavicular syndrome: Pain with horizontal adduction and/or outward rotation of arm. Exposure: Videotaping and observation. Analysis of elevation of the arm: 0E, 30E, 60E, and for abduction 30E, 60E, 90E. 74 workers videotaped $10 min. from back and sides. Average counts of two inde-pendent readers for frequencies, duration, and critical angles of movement used. Repetitive industrial work tasks divided into 3 groups: (a) fairly mobile work, (b) assembling or pressing items, and © sorting, polishing and packing items Weekly working time, work rotation, patterns of breaks, individual performance rate (piece rate). Only exposure readings from right arm were used. Muscle strength (maximum voluntary capacity) measured by hand dynamometer at elevation,	50% (n=82) Employment duration: <10 years (n=19): 53% 10 to 19 years (n=25): 48% >20 years (n=38): 50%	16% (n=64)	5.0 9.6 4.4 3.8	2.2-11.0 2.8-33.0 1.5-13.0 1.4-10.0	Participation rate: current workers: 96%; past workers: 86%; referents: 100%. Questionnaire included individual factors, work/environment, symptoms. No exposure information available to examiners, however, it was not possible to completely blind the study/referent group status. Psychosocial scales assessed: control over one's work, stimulation, psychological climate, work strain, fellowship at work and social network at work. Age, stress/worry tendency, subjective muscular tension tendency, social network outside of work, psychosomatic symptoms. Age and employment status (repetitive vs. referent) controlled for in logistic model. For continuous variables, OR are for 75th vs. 25th percentiles. Videotape analysis revealed considerable variation in posture even within groups performing similar assembling tasks. Logistic models replacing repetitive work with videotape variables found muscular tension tendency and neck flexion movements significantly associated with neck/shoulder diagnoses. Significant association between time spent with upper arm abducted >60° and neck/shoulder diagnoses.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

				MSD prevalence				
Study	Study design	Study population	Outcome and exposure	Exposed workers	Referent group	RR, OR, or PRR	95% CI	Comments
Onishi et al. 1976	Cross-sectional	Female industrial workers: 42 reservationists; 95 fluorescent lamp assemblers; 109 photographic film rollers; 46 teachers of handicapped children; 101 office workers.	Outcome: Based on (1) symptoms of shoulder stiffness, dullness, pain, numbness; (2) pressure (<1.5 kv/cm^2) measured by strain transducer at which subject felt pain. (3) physical exam: range of motion, tests, nerve compression tenderness.	Shoulder Tenderness:				Participation rate: Not reported. Unknown whether examiners blinded to case status.
				Reserva-tionists: assemblers: 70%	Office workers (n=101): 48%	1.1	0.6-1.9	Body height, weight skin fold thickness and muscle strength, grip strength, obtained.
			Exposure: Observation of job tasks, then job categorization.	Film rollers: 84%		6.0	3.0-12.2	Body height and weight differences not significant.
			Reservations; Key 15,000 to 20,000 strokes/day or more on busy days 2 to 3 times/week.	Teachers: 58%		1.6	0.7-3.3	Significant difference between body fat in reservationists and office workers.
				Shoulder Stiffness:				Significant difference in grip strength in teachers and nurses compared with office workers.
			Assemblers inspect lamps once every 3.5 to 4.5 sec; all work 12 hr/day. Film rollers wind 1 roll of 35mm film every 2.5 to 5 sec over 7.5 hr/day.	Reservatio-nists (N=45): 56.6%	34.7%	2.5	1.1-5.6	Those with habitual shoulder stiffness had lower threshold of local tenderness than those without stiffness.
			Prolonged contraction of trapezius noted in 2 film rollers.	Assemblers (N=94): 66.6%		3.7	2.0-7.0	No difference between workers with tenderness threshold above 1.5 Kb/cm^2 and those below with respect to age, height, weight, skin fold thickness, grip strength, upper arm abduction strength, back muscle strength.
			Teachers and nurses daily care of disabled children e.g., lifting.	Film Rollers (N=127): 59.1%		2.7	1.5-4.9	
			Office workers: Record keeping, copying, etc.	Teachers (N=52): 65.4%		2.1	0.9-4.6	

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

				MSD prevalence				
Study	**Study design**	**Study population**	**Outcome and exposure**	**Exposed workers**	**Referent group**	**RR, OR, or PRR**	**95% CI**	**Comments**
Punnett et al. 1985	Cross-sectional	162 female garment workers, 85% were employed as sewing machine operators and sewing and trimming by hand. Comparison: 76 of 190 full or part-time workers on day shift in a hospital who worked as nurses or aids; lab techs or therapists; food service workers. Employees typing >4 hr/day excluded from comparison group.	Outcome: Self-administered questionnaire about pain and standardized physical exam. Cases defined as the presences of persistent shoulder pain (lasted for most days for one month or more within the past year); were not associated with previous injury, and, began after first employment in garment manufacturing or hospital employment. Key questions based on the arthritis supplement questionnaire of NHANES. Exposure: Self-administered questionnaire; number of years in the industry, job category, previous work history.	Garment workers: 19.6%	Hospital employees 8.8%	Shoulder MSDs in Garment workers vs. Hospital employees: OR= 2.2 Shoulder MSDs in Straight stitch workers vs. Hospital employees: OR=3.9 Shoulder MSDs in Top stitch workers vs. Hospital employees OR=5.0	1.0-4.9 *p*#0.05 *p*#0.05	Participation rate: 97% (garment workers), 40% (hospital workers). Analysis stratified for number of years employed, decade of age, native language. Age and length of employment not a predictor of risk of shoulder MSDs. Prevalence of pain not associated with years of employment in garment workers. Non-English speakers significantly less likely to report pain (RR 0.6 *p*<0.05). Native English speakers significantly older than non-native English speakers (*p*<0.03). Logistic regression model found garment work and language significantly related to shoulder pain.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	Referent group	RR, OR, or PRR	95% CI	Comments
Rossignol et al. 1987	Cross-sectional	191 computer and data processing services, public utilities of Massachusetts State Department, 28 of whom did not use a keyboard with a VDT. Centers selected at random from 38 work sites with >50 employees.	Outcome: Self-administered questionnaire case defined as: "Almost always experienced" shoulder pain, stiffness or soreness or missed work due to shoulder pain, stiffness or soreness. Exposure: Self-reported number of hr/day working on a keyboard with a VDT. Subjects selected after observation of work sites.	0.5 to 3 hr of VDT use/day (n=31): 35% 4 to 6 hr of VDT use/day (n=28): 48% >7 hr of VDT use/day (n=104): 51%	Comparison group (with no computer use) (n=28): 18%	Up to 3 hr of VDT use compared to 0 hr of use. OR=2.5 4 to 6 hr of VDT use compared to 0 hr of use: OR=4.0 >7 hr of VDT use compared to 0 hr of use: OR=4.8	0.7-10.8 1.0-16.9 1.6-17.2	Participation rate: in six industry groups 67 to 100%. Participation rate: for individual clerical workers: 94 to 99%. "Assessed magnitude of confounding by age, cigarette smoking, industry, educational VDT training." The study was presented as "General health survey to avoid observation bias."

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

				MSD prevalence				
Study	Study design	Study population	Outcome and exposure	Exposed workers	Referent group	RR, OR, or PRR	95% CI	Comments
Sakakibara et al. 1987	Cross-sectional	48 Orchard workers (20 males and 20 females). Compared symptoms after completion of thinning of pears, bagging of pears and bagging of apples (covering fruit with paper bags while on the trees). Internal comparison using same study population.	Outcome: Shoulder pain described as the presence of stiffness and pain daily. Exposure: Observation of jobs. Angles of flexion of the shoulder on one subject were measured every 25 min. during a whole day doing each task. Farmers worked approximately 8 hr/day for 10.6 to 13.6 days each year bagging or thinning pears and bagging apples. Median shoulder flexion was 110E to 119E for thinning pears and bagging pears; 30E bagging apples.	Workers thinning pears (estimated from histograms): 46% Workers bagging pears (estimated from histograms): 29%	Workers bagging apples: 21%	Workers thinning pears vs. workers bagging apples: OR=2.2 Workers bagging pears vs. bagging apples: OR=1.4	1.2-4.1 0.7-2.8	Participation rate: 77%. Stratified by gender. General fatigue, gastric disturbances, appetite loss and headache showed no difference in frequency between tasks. Stiffness and pain in shoulders significantly higher from thinning and bagging pears than apples which authors attributed to working posture of elevated arms and neck extension. Exposure data based on measurement of one worker may not be generalized to others. The proportion of workers with >90E forward shoulder flexion was significantly higher for thinning out pears and bagging pears than for bagging apples.

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				MSD prevalence				
Study	Study design	Study population	Outcome and exposure	Exposed workers	Referent group	RR, OR, or PRR	95% CI	Comments
Sakakibara et al. 1995	Cross-sectional	Of 65 female Japanese farmers. 52 completed the questionnaire and physical exam in late June for bagging pears and late July for bagging apples.	Questionnaire: Stiffness and pain in shoulder region. Symptoms in past 12 months for $one day, or symptoms in past 12 months for $8 days. Exam: Muscular tenderness in shoulder region; maximal grasping power measured by dynamometer and back muscle power by myosphenometer. Exposure: Observation of tasks and measurements of representative workers (only two workers measured). Angle of arm elevation during bagging was measured in one subject. Angle of forward flexion of shoulder for bagging pears was 110 to 139°. 75% of angles were above 90°. For bagging apples the angle of forward flexion was 0 to 140°; 41% of the angles were >90°.	Pear bagging Muscle tenderness: 48.1% Pain in joint motion: 23.1%	Apple bagging Muscle tender-ness: 28.8% Pain in joint motion: 21.2% controls	Workers bagging pears with muscle tenderness vs. apple bagging with muscle tenderness: OR=1.7 Workers bagging pears with pain in joint motion vs. apple bagging with pain in joint motion: OR=1.1	1.1-2.9 0.53-2.3	Participation rate: 80%. Examiners not blinded to case status due to design of study. Same population examined two times. 2nd exam occurred one month after first. These results used in analyses for comparison of two tasks. Stiffness and pain during apple bagging may have been pain that was a residual of pear bagging operations. Number of fruit bagged/day was significantly more in pear bagging than in apple bagging. Exposure measurements only obtained on 2 workers and generalized to all workers.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Schibye et al. 1995	Pro-spective	Follow-up of 303 sewing machine operators at nine factories representing different technology levels who completed questionnaire in 1985. In April 1991, 241 of 279 traced workers responded to same questionnaire.	Outcome: Cases defined by the Nordic questionnaire for symptoms as to duration during last 12 months and during last 7 days, effect on work performance and leisure activities, and sick leave. Exposure: Assessed by questions regarding type of machine operated, work organization, workplace design, units produced/day, and payment system, time of employment as a sewing machine operator.	Workers who delivered or collected their own materials: 18% shoulder symptoms; the rest 33%	õ	õ	õ	Participation Rate in 1985: 94%. Participation Rate in 1991: 86%. All participants were female. 77 of 241 workers still operated a sewing machine in 1991. 82 workers had another job in 1991. Among those 35 years or younger, 77% had left their jobs; among those above 35 years, 57% had left their jobs. 20% reported musculoskeletal symptoms as the reason for leaving job. No significant changes in prevalences among those employed as sewing machine operators from 1985 to 1991; significant decrease in those who changed employment.

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Stenlund et al. 1992	Cross-sectional	55 of 75 rockblastors, 54 of 75 bricklayers randomly selected from union records and 98 of 110 foremen selected from foremen employed in large construction firms.	Outcome: Based on a grading of acromioclavicular joints of shoulders. Grade 0 = normal Grade 1 = minimal changes Grade 2 = moderate changes Grade 3 = severe osteoarthritis Grade 4 = joint destroyed Exposure: Based on self-reported estimates of loads lifted, hr of exposure to vibration, job title, and years of employment. The weights of tools also obtained. Bricklayers lifted a mean of 29,439 tonnes; Rockblasters, a mean of 33,210 tonnes; Foremen, a mean of 2,261 tonnes.	Bricklayers Rt side: 59.3% Lt side: 40.7% Rockblasters Rt side: 61.8% Lt side: 56.4%	Foremen 36.7% 23.4% Foremen 36.7% 23.4%	 2.2 1.8 2.1 4.0 Years of manual work >28 years vs. <10 years Rt side: 2.9 Lt side: 2.5 10 to 28 years vs. <10 years Rt side: 1.1 Lt side: 2.3 Load lifted 725,000 vs. 710 tonnes Rt side: 3.2 Lt side:10.3 Vibration 725,000 hr vs <9001 hr Rt side: 2.2 Lt side: 3.1	 1.0-4.7 0.8-3.9 0.9-4.6 1.8-9.2 1.2-7.4 1.0-5.9 1.1-4.7 1.0-5.3 1.1-9.2 3.1-34.5 1.0-4.6 1.4-6.9	Participation rate: 80%. Classification of X-rays achieved with blinding of investigators to age, name or exposure status. Study looked at manual work and exposure to vibration and relationship to osteoarthritis in acromioclavicular joint using shoulder x-rays. Logistic regression models adjusted for age, smoking, dexterity, checked for interactions. Questionnaire included questions about smoking, dexterity, ethnicity, citizenship. Risks were elevated as length of employment increased and as exposure to vibration and amount lifted increased. X-ray grades 2 and 3 for analysis. Smoking significantly associated with osteoarthritis of right shoulder (OR=2, 2.4) but not left side. Significance found, but is it meaningful? Left handedness significantly associated with osteoarthritis of left side (OR=2.5). The age adjusted odds ratio for osteoarthrosis in the right acromioclavicular joint for brick layers and rock blasters as compared with foremen, was 2.16 on the right side 95%CI(1.14-4.09), and was 2.56 95% CI (1.33-4.93).

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Stenlund et al. 1993	Cross-sectional	55 of 75 rockblasters and 54 of 75 bricklayers selected randomly from union records, and 98 of 110 foremen randomly selected from foremen employed in large construction companies.	Outcome: Based on questionnaire of previous injuries and diseases of musculoskeletal system and previous shoulder pain, and physical exam.	Bricklayers	Foremen			Participation rate: 80%.
				Rt. side: 11.1%;	8.2%	0.4	0.2-1.3	Examiners blinded to exposure status or job title.
				Lt. side: 14.8%	17.1%	õ	õ	Unconditional multiple regression analysis adjusted for age, handedness, smoking and sport activities. In all models left and right sides calculated separately.
			Case defined as "Signs of shoulder tendinitis" as palpable pain of the muscle attachment or pronounced pain reaction to isometric contraction in any of the 4 rotator cuff muscles or biceps muscles.	Rockblasters Rt. side: 32.7%	8.2%	1.7	0.7-4	
				Lt. side: 40.0%	17.1%	3.3	1.2-9.3	Vibration related to shoulder tendinitis although confounded by static loads and lifting.
			"Clinical entity of tendinitis" defined as pain during the last year, pronounced pain reaction to palpation or isometric contraction.			Clinical Entity Load Rt. side: 1.0 Lt. side: 1.6	 0.5-2.2 0.6-4.1	Interactions tested for.
			Exposure: Based on self-reported estimates of load lifted, hr of exposure to vibration, job title and years of employment.			Vibration Rt. side: 1.9 Lt. side: 2.5	 1.0-3.4 1.1-5.9	The study looked at manual work and exposure to vibration and their relationship to signs of tendinitis of the shoulder.
						Manual Work Rt. side: 0.9 Lt. side: 2.3	 0.5-1.8 0.9-6.3	Exposure-response found where comparison of high vibration exposure compared to low exposure.
			Load defined as 0 to 709 tonnes, 710 to 25,999 tonnes, >25,999 tonnes vibration defined as hr of exposure: 0 to 8,999, 9000 to 255,199, >255,999 hr to each tool multiplied by factor corresponding to vibration energy. Years of manual work: 0 to 9, 10 to 28, >28 years.			Signs of Tendinitis Load Rt. side: 1.0 Lt. side: 1.8	 0.6-1.8 0.9-3.4	
						Vibration Rt. side: 1.7 Lt. side: 1.8	 1.1-2.6 1.1-3.1	
						Manual Work Rt side: 1.1 Lt side: 1.9	 0.7-1.8 1.0-3.4	

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

				MSD prevalence				
Study	Study design	Study population	Outcome and exposure	Exposed workers	Referent group	RR, OR, or PRR	95% CI	Comments
Sweeney et al. 1994	Cross-sectional	105 of 164 sign language interpreters for the deaf, who attended a professional conference of sign language interpreters.	Outcome: Symptom questionnaire and physical exam:	Symptom case: 22%				Participation rate: 64%.
			Symptom case defined as the presence of pain, aching, stiffness, burning, numbness or tingling in the shoulder lasting $ one week or once/month within the past 12 months; no previous injury and symptoms occurred after becoming a sign-language interpreter.	Symptom case with moderate to severe shoulder discomfort: 50%	>20 hr signing, compared to <10 hr/week	2.5	0.8- 8.2	Examiner blinded to exposure status. Generalizability of results to other sign language interpreters is limited.
			Symptom-exam case: Defined as the presence of symptoms and a positive exam for the shoulder.	Positive symptom + positive exam: 1%	ð	ð	ð	
			Exposure: Based on questionnaire (years of employment as a sign language interpreter; numbers of hrs/week engaged in signing).					

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Table 3-5 (Continued). Epidemiologic studies evaluating work-related shoulder musculoskeletal disorders

Study	Study design	Study population	Outcome and exposure	MSD prevalence: Exposed workers	MSD prevalence: Referent group	MSD prevalence: RR, OR, or PRR	MSD prevalence: 95% CI	Comments
Wells et al. 1983	Cross-sectional	Of 199 letter carriers, 196 were compared to 76 of 79 meter readers and 127 of 131 postal clerks.	Outcome: Telephone interview based on current pain; frequency, severity, interference with work, etc; score of 20 required to be a case. More points given to neck and shoulder problems that interfered with routine daily activities.	All letter carriers: 18%	Postal clerks: 5%	3.6	1.8-7.8	Participation rate: 99% among letter carriers, 92% meter readers, 97% postal clerks. Schooling and marital status asked.
				Letter carriers: increased weight: 23%	Postal clerks: 5%	5.7	2.1-17.8	Symptoms alone used for MSD definition.
			Exposure: Based on job category; based on self-reported information on weight carried, previous work involving lifting and work-related injuries.	Letter carriers: no weight increase: 13%	Postal clerks: 5%	3.3	1.1-11.1	Comparison group (gas meter readers) used because of similar "walking rate" without carrying weight compared to letter carriers. Postal clerks neither walk nor carry weight. During analysis, more weight was given to scoring neck and shoulder than other body regions. Outcome influenced results when ranking of body MSDs, though, would not influence group comparison. Adjusted for age, number of years on the job, quetlet ratio and previous work experience. 104 letter carriers had bag weight increased from 25 to 35 lbs in the year prior to the study. Letter carriers with increased bag weight walked on average 5.24 hr; those with no change in bag weight walked 4.83 hr. Letter bags usually carried on the shoulder.